UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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LABORATORY SERVICES &
APPLIED SCIENCE
DIVISION

MEMORANDUM

SUBJECT: Review of Best Available Control Technology analyses submitted for the University of Alaska, Fairbanks as part of the Fairbanks PM2.5 Nonattainment SIP

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TO: Matthew Jentgen, ARD

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1. Introduction

The University of Alaska, Fairbanks (UAF) is located in Fairbanks, and includes multiple boilers and engines and a pathogenic waste incinerator in addition to the campus power plant. The BACT analysis is primarily focused on sulfur dioxide emissions from the new (2019) dual-fired (coal and biomass), circulating fluidized bed (CFB) boiler rated at 295.6 million British thermal units per hour heat input (MMBtu/hr) which is operated for power and steam heat generation for the campus. The CFB boiler was constructed to replace two coal fired boilers installed in 1962.

The Alaska Department of Environmental Conservation (ADEC) BACT determination submitted in the Serious SIP found that no additional controls or emission reductions would be required for nitrogen oxides (NOx) and fine particulate matter (PM2.5). Some new emission limits for PM2.5 were put in place, but no new controls were required. The BACT determination for sulfur dioxide (SO2) found that combustion of ultra-low sulfur diesel (ULSD) in all boilers and engines and in the incinerator was technically feasible and cost effective and would be required as BACT. For the CFB boiler, ADEC found that while installation of dry sorbent injection (DSI) was technically feasible and cost effective, this control technology would not be required for the CFB boiler because it would cause an adverse economic impact to UAF.

2. BACT Review History

Formal EPA review of the BACT analyses conducted as part of the Fairbanks PM2.5 SIP began with a review of the draft SIP materials in the spring of 2018. Comments were provided to ADEC via letter dated May 21, 2018. A revised Proposed Plan was released for public review on May 10, 2019, and EPA provided formal comments via letter dated July 19, 2019. The Serious PM2.5 SIP was submitted to EPA on December 13, 2019 and amended on December 15, 2020 (189(d) Plan). EPA also provided formal comments regarding BACT requirements for the 189(d) Plan on October 29, 2020. As discussed further below, ADEC did not adequately address EPA's formal comments. Therefore, ADEC's rejections of certain feasible SO2 controls was not adequately justified. Accordingly, EPA Region 10 engaged directly with UAF during 2021-2022 to request additional cost information necessary to justify ADEC's rejection of feasible SO2 controls. UAF has engaged consultant support and is working to develop additional information for submittal to EPA, but no additional information has been submitted to date.

3. EPA Comments on Draft Serious SIP – May 21, 2018 – UAF

The following comments were provided to ADEC via letter dated May 21, 2018[1]. Selected comments are included here since they form a significant portion of the technical issues related to the UAF BACT analysis.

Site-Specific Quotes Needed – The cost analyses, particularly for SO2 control technologies, must be based on emission unit-specific quotes for capital equipment purchase and installation costs at each facility. These are retrofit projects which must be considered individually in order to obtain reliable study/budget level (+/- 30%) cost estimates which are appropriate to use as the basis for decision making in determining BACT and potentially MSM. EPA believes that control decisions of this magnitude justify the relatively small expense of obtaining site-specific quotes.

SO2 Control Technologies – The analyses must include evaluation of circulating dry scrubber(CDS) SO2 control technology. This demonstrated technology can achieve SO2 removal rates comparable to wet flue gas desulfurization (FGD) at lower capital and annual costs, and is more amenable to smaller units and retrofits. Modular units are available.

Control Equipment Lifetime – The analyses must use reasonable values for control equipment lifetime, according to the EPA control cost manual (EPA CCM). EPA believes that the following equipment lifetimes reflect reasonable assumptions for purposes of the cost analysis for each technology as stated in the EPA control cost manual and other EPA technical support documents. Use of shorter lifetimes for purposes of the cost analysis must include evidence to support the proposed shortened lifetime. One example where EPA agrees a shortened lifetime is appropriate would be where the subject emission unit has a federally enforceable shutdown date. Certain analyses submitted in the past have claimed shortened equipment lifetimes based on the harshness of the climate in Fairbanks. In order to use an equipment life that is shortened based on the harsh climate, evidence must be provided to support the claim. This evidence could include information regarding the actual age of currently operating control equipment, or design documents for associated process equipment such as boilers. Lacking adequate justification, all cost analyses must use the following values for control equipment lifetime.

- *SCR, Wet FGD, DSI, CDS, SDA – 30 years*
- *SNCR – 20 years*

Availability of Control Technologies – Technologically feasible control technologies may only be eliminated based on lack of availability if the analysis includes documented information from multiple control equipment vendors (who provide the technology in question) which confirms the technology cannot be available within the appropriate implementation timeline for the emission unit in question.

Assumptions and Supporting Documents – All documents cited in the analyses which form the basis for costs used and assumptions made in the analyses must be provided. Assumptions made in the analyses must be reasonable and appropriate for the control technologies included in the cost analysis.

Interest Rate – All cost analyses must use the current bank prime interest rate according to the revised EPA CCM. As of May 10, 2018, this rate is 4.75%. See https://www.federalreserve.gov/releases/h15/ (go to bank prime rate in the table).

<u>Space Constraints</u> – In order to establish a control technology as not technologically feasible due to space constraints or other retrofit considerations, detailed site specific information must be submitted in order to establish the basis for such a determination, including detailed drawings, site plans and other information to substantiate the claim.

<u>Retrofit Factors</u> – All factors that the facility believes complicate the retrofit installation of each technology should be described in detail, and detailed substantiating information must be submitted to allow reasonable determination of an appropriate retrofit factor or whether installation of a specific control technology is technologically infeasible. EPA Region 10 believes that installation factors which would complicate the retrofit installation of the control technology should be evaluated by a qualified control equipment vendor and be reflected in a site-specific capital equipment purchase and installation quote. Lacking site-specific cost information, all factors that the facility believes complicate the retrofit installation of each technology should be described in detail, and detailed substantiating information must be submitted to allow reasonable determination of an appropriate retrofit factor. One example of the many retrofit considerations that must be evaluated is the footprint required for each control technology. A vendor providing a wet scrubber will be able to estimate the physical space required for the technology, and evaluate the existing process equipment configuration and available space at each subject facility. The determination of whether a specific control technology is feasible and what the costs will be may be different at each facility based on this and other factors. Site-specific evaluation of these factors must be conducted in order to provide a reasonable basis for decision making.

<u>Control Efficiency</u> – Cost effectiveness calculations for each control technology must be based on a reasonable and demonstrated high end control efficiency achievable by the technology in question at other emission units, or as stated in writing by a control equipment vendor. If a lower pollutant removal efficiency is used as the basis for the analysis, detailed technical justification must be provided. For example, the ability of SCR to achieve over 90% NOX reduction at coal-fired power plant boilers is well established, yet the ADEC draft analyses assume only 80% control. Use of this lower control efficiency requires robust technical justification.

4. EPA Comments on Proposed Serious SIP – July 19, 2019 – UAF

Following submittal of the Proposed Serious SIP, EPA provided follow-up comments to ADEC via letter dated July 19, 2019[2]. Selected comments from the 2019 letter are included below related to UAF and the BACT analyses generally.

In 2018, EPA provided comments based on the preliminary drafts of this Serious area plan. While EPA appreciated the time and effort invested by ADEC staff in preparing the draft BACT analyses in 2018, the majority of the basic cost and technical feasibility information identified in our prior comments as necessary to form the basis for retrofit BACT analyses at the specific facilities has not been provided by the point sources or in the proposed plan. Although limited (while still insufficient) cost information has been provided for dry sorbent injection (DSI), no site-specific quotes have been provided for the other three, higher performing SO2 control technologies. We summarize key points from EPA's 2018 comment letter here and have included for resubmission the full letter as a KEY COMMENT in Attachment 1 of this letter. Below we cite some key missing elements from the existing BACT analysis.

The 2019 letter includes a re-statement of EPA's 2018 comments regarding site-specific quotes, control equipment lifetime, and control efficiency. Additionally, the following comments specific to the UAF BACT analysis are included:

<u>Economic infeasibility.</u> An economic infeasibility determination is a possible outcome of the BACT process. Developing an adequate economic infeasibility assessment to support an approvable BACT determination should include the following:

- *We recommend at least two site specific vendor quotes for each control technology.*
- *We recommend economic infeasibility assessments developed using economic theories include appropriate analysis of potential impacts on relevant markets and products (e.g., price elasticity of demand for electricity).*
- *Financial information/discussion for the source that, when compared to the cost of the control, helps address the question concerning the economic feasibility of the control technology for the specific source. If such information is considered to be CBI, then there are mechanisms authorized under the Clean Air Act by which that information can be collected and protected from public disclosure.*
- *EPA-approved control cost effectiveness analysis and economic infeasibility assessment.*

In order for EPA to review ADEC's finding that additional SO2 controls are economically infeasible, the state or UAF will need to provide an economist developed infeasibility submittal as described in the section BACT-General, above.

<u>BACT Determination.</u> In the 2018 preliminary plan DSI was selected as BACT. In addition to economic infeasibility, technological infeasibility was also cited in this 2019 plan, which asserts that the facility could not efficiently be retrofitted with a new control technology. However, the conclusion assumes the source must achieve a high-end control efficiency from DSI and that achieving such a control efficiency is not technologically feasible due to the need to inject excess sorbent into the ducting, with the resulting negative impacts. We recommend that the BACT analysis instead evaluate the cost effectiveness of DSI based on the level of control efficiency practicable given the current infrastructure in addition to evaluating the cost effectiveness of retrofitting the ductwork to achieve higher control efficiency via DSI and other SO2 control technologies.

5. Summary of the December 2019 BACT Submittal – UAF

5.1. Introduction

The Best Available Control Technology (BACT) analysis for the UAF Campus emission units was submitted as part of the December 13, 2019 Fairbanks SIP submission and is summarized within Chapter III.D.7.07 Control Strategies[3]. The general discussion of BACT for the large stationary sources begins on page III.D.7.7-36 and the section pertaining specifically to UAF begins on page III.D.7.7-80. In addition, Appendix III.D.7.07 Control Strategies Part 3 incorporates supporting documentation, including multiple Excel spreadsheets containing cost analyses. Refer to the appendix for a listing of the specific supporting documents.

5.2. Nitrogen Oxides (NOx)

The BACT analysis assumed EPA approval of the precursor demonstration for NOx, and, based on the findings of that demonstration, therefore proposed no additional control for all emission units.

5.3. Fine Particulate Matter (PM2.5)

5.3.1. Circulating Fluidized Bed, Dual Fuel (coal and biomass) Boiler (CFB Boiler)

For the CFB boiler at the Campus Power Plant, the BACT analysis determined that the existing baghouse and associated emission limit of 0.012 pounds of PM2.5 per million British Thermal Units if heat input (lb/MMBtu), averaged over 3-hours, constituted BACT. No additional controls were proposed.

5.3.2. Diesel-Fired Engines

For diesel fired engines, the BACT analysis established limits on PM2.5 emissions ranging from 0.015 – 1.0 grams per horsepower-hour (g/hp-hr), averaged over 3-hours. Half of the emission units in this category are subject to limits on annual hours of operation, which reduces the potential emissions. Specifically, the analysis evaluated 6 units rated at 500 hp or less. Three units (EUs 24, 28, and 29) were limited to no more than 100 hours of operation per year. EU 27 was limited to 4,380 hours per year and EUs 23 and 26 were not subject to limits on hours of operation.

A BACT analysis was conducted for EU27 which identified the following PM2.5 control technologies as available and technically feasible:

- Diesel Particulate Filters (DPF) – 60-90% control
- Diesel Oxidation Catalyst – 40% control
- Low ash diesel – 25% control
- Good combustion practices – less than 40% control
- Limited operation – 0% control[4]
- Federal emission standards – Baseline

The BACT analysis included a cost effectiveness analysis prepared by UAF[5] for DPF based on a quote from NC Power Systems[6]. Selected cost elements from the UAF cost effectiveness analyses are summarized below.

- The calculations used an interest rate of 7%, and an equipment life of 10 years.
- The baseline annual emissions used were 0.26 tons per year. The specific calculations used to produce this baseline emissions rate were not provided.
- Control efficiency of the DPF was assumed to be 85%, resulting in 0.22 tons per year of PM2.5 removed for purposes of the cost analysis.
- UAF's cost analysis resulted in TCI of $30,751 and no annual operating and maintenance costs were assumed. UAF's calculated cost effectiveness was $19,811/ton.

ADEC modified the UAF cost analysis in the 2019 SIP to use a 20 year equipment life, changing the calculated cost effectiveness to $13,139/ton. ADEC concluded that the level of PM2.5 reduction does not justify the installation of DPF on EU27.

No cost analyses were provided for EUs 23 and 26.

UAF also operates a single, much larger, diesel engine rated at 13,266 horsepower (EU 8). PM controls such as DPF were not evaluated. ADEC's PM2.5 BACT determination for EU 8 includes the following:

- PM2.5 emissions from EU 8 shall be controlled by operating positive crankcase ventilation and combusting only low ash diesel at all time of operation;

- Limit NOx emissions from EUs 4 and 8 to no more than 40 tons per year combined;
- Limit non-emergency operation of EU 8 to no more than 100 hours per year; and
- PM2.5 emissions from EU 8 shall not exceed 0.32 g/hp-hr averaged over a 3-hour period.

5.3.3. Diesel-Fired Boilers

For the mid-sized diesel-fired boilers (EUs 3 and 4), the BACT analysis established limits on PM2.5 emissions of 0.012 lb/MMBtu, averaged over 3-hours. EU 4 can also burn natural gas, and so an alternate emission limit of 0.0075 lb/MMBtu was established for this operating scenario. The BACT analysis determined that no additional controls would be proposed for PM2.5 for these two units, relying on good combustion practices as BACT. Additionally, EU 4 is subject to a combined NOx emission limit of 40 tons per year with EU 8 (large diesel engine discussed above). This amounts to an operational limit for EU 4. EU 3 is not subject to any operational limits. In their BACT analysis for PM2.5 emissions from the mid-sized boilers, ADEC did not identify any available control technologies other than good combustion practices. Review of the BACT analysis submitted by UAF indicates that fabric filters, electrostatic precipitators, wet scrubbers and cyclones were all determined to be not technically feasible[7].

For the small diesel-fired boilers (EUs 19-21), the BACT analysis established limits on PM2.5 emissions of 0.012 lb/MMBtu, averaged over 3-hours. These three boilers are also subject to a limit on combined annual operation of 19,650 hours.

A BACT analysis was conducted for EUs 19-21 which identified the following PM2.5 control technologies as available and technically feasible:

- Scrubber – 70-90% control
- Good combustion practices – less than 40% control
- Limited operation – 0% control

The BACT analysis included a cost effectiveness analysis prepared by UAF[8] for a scrubber based on a quote from Proctor Sales, Inc.[9]. Selected cost elements from the UAF cost effectiveness analyses are summarized below.

- The calculations used an interest rate of 7%, and an equipment life of 10 years.
- The baseline annual emissions used were 0.9 tons per year. The specific calculations used to produce this baseline emissions rate were not included in the 2019 SIP submittal.
- Control efficiency of the scrubber was assumed to be 99%, resulting in 0.891 tons per year of PM2.5 removed for purposes of the cost analysis.
- No costs other than the annualized Purchased Equipment Cost (PEC) were included in the analysis.
- UAF's cost analysis resulted in TCI of $300,000 and no annual operating and maintenance costs were assumed. UAF's calculated cost effectiveness was $47,939/ton.

ADEC concluded that the level of PM2.5 reduction does not justify the installation of a scrubber on EUs 19-21.

5.3.4. Pathological Waste Incinerator

For the incinerator (EU 9A), the BACT analysis established a limit on PM2.5 emissions of 4.67 lb/ton. No averaging period for this emission limit was specified. An operational limit of 109 tons of waste burned per year was also established. The BACT analysis determined that no additional controls would be proposed for PM2.5 for the incinerator, relying on multiple combustion chamber design, good combustion practices, and following manufacturer's operating procedures as BACT.

The BACT analysis identified the following PM2.5 control technologies as available and technically feasible:

- Fabric filter – 99.9% control
- Good combustion practices – less than 40% control
- Multiple chamber design – 0% control
- Limited operation – 0% control

The BACT analysis included a cost effectiveness analysis prepared by UAF[10] for a fabric filter based on a verbal cost estimate from Thermtec, Inc., the incinerator manufacturer[11]. Selected cost elements from the UAF cost effectiveness analyses are summarized below.

- The calculations used an interest rate of 7%, and an equipment life of 10 years.
- The baseline annual emissions used were 0.3 tons per year. The specific calculations used to produce this baseline emissions rate were not included in the 2019 SIP submittal. This baseline emission rate appears to be approximately consistent with the unit combusting 109 tons of waste per year with an emission rate of 4.67 lbs/ton.
- Control efficiency of the fabric filter was assumed to be 99.9%, resulting in 0.285 tons per year of PM2.5 removed for purposes of the cost analysis.
- No costs other than the annualized Purchased Equipment Cost (PEC) were included in the analysis.
- UAF's cost analysis resulted in TCI of $1,300,000 and no annual operating and maintenance costs were assumed. UAF's calculated cost effectiveness was $761,441/ton.

ADEC concluded that the level of PM2.5 reduction does not justify the installation of a fabric filter on EU 9A.

5.3.5. Material Handling

For various material handling (EUs 105, 107, 109, 110 & 128-130), ash loadout to truck (EU 111), and sorbent handling (EU 114) emission units, ADECs BACT analysis established limits on PM2.5 emissions ranging between 0.003 – 0.050 grains per dry standard cubic foot of exhaust gas (gr/dscf). For the ash loadout, the limit is specified as 5.5E-05 lb/ton. Control measures determined to constitute BACT include enclosing the emission unit and routing the emissions to a fabric filter. An initial compliance test is required. This control determination applies to all material handling EUs with the exception of EU 111 (ash loadout to truck), where only enclosure is required (no fabric filter nor emission testing).

5.4. SO2 BACT Analysis – General Summary

For the CFB boiler, the BACT analysis determined that all SO2 emission controls were economically infeasible. ADEC determined that BACT would consist of the existing emission limit of 0.20 lb/MMBtu (30-day rolling average), good combustion practices, following manufacturer's operating and maintenance procedures, and combustion of low sulfur coal. Gross, as received, [a]sulfur content of the coal is limited to 0.25% by weight starting on June 9, 2021. The BACT analysis for SO2 for the CFB boiler is discussed in further detail below.

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[a] We note a sulfur content limit must be on a dry basis, or actual limit will vary with coal moisture content.

For all diesel-fired emission units (boilers, engines, and the incinerator), the BACT analysis determined that combustion of ULSD as the only permitted fuel in these units would constitute BACT. The analysis established a fuel sulfur content limit of 15 ppm by weight.

5.5. SO2 BACT Analysis – CFB Boiler (EU 113)

The BACT analysis identified the following SO2 control technologies as available and technically feasible for the CFB boiler at UAF:

- Wet scrubbers – 99% control
- Spray dry absorbers (SDA) – 90% control
- Dry sorbent injection (DSI) – 50-80% control
- Good combustion practices – less than 40% control
- Limestone injection – 0% control
- Low sulfur coal – 0% control

The BACT analysis included cost effectiveness analyses[12] prepared by ADEC for the top three control options evaluated: wet scrubbing, SDA, and DSI. For all three technologies, ADEC utilized Integrated Planning Model (IPM) cost estimation spreadsheets developed by Sargent & Lundy for EPA. UAF provided site specific quotes for DSI and SDA obtained from Babcock & Wilcox (B&W) in 2016[13], but ADEC did not use either quoted cost in their cost effectiveness analyses. No site-specific cost estimates or vendor quotes were included for wet scrubbing. No cost analysis was submitted for circulating dry scrubbing (CDS).

Selected cost elements from the ADEC cost effectiveness analyses and vendor quotes are summarized below.

5.5.1. Dry Sorbent Injection (DSI)

- The ADEC spreadsheet used a unit size of 29.6 megawatts (MW).
- A retrofit factor of 1.0 was used, assuming a retrofit of average difficulty.
- The DSI system was assumed to use milled Trona, and achieve 80% SO2 control efficiency.
- The baseline emissions rate used was 0.2 lb/MMBtu (pounds of SO2 per million British Thermal Units of coal combusted) based on the current emission limit. According to ADEC's calculations, this baseline emissions rate resulted in annual SO2 emissions of 259 tons per year (tpy) and SO2 removed of 207 tpy, assuming 80% control efficiency.
- The calculations used an interest rate of 5%, and an equipment life of 15 years.
- ADEC's cost analysis resulted in TCI[14] of $5,192,915 and annual operating and maintenance costs of $1,256,331[15].
- The Total Annualized Cost was escalated from cost year 2012 (cited as the cost year of the IPM equation) to cost year 2016 (cited as the cost year of the analysis). The escalation used "Composite" cost effectiveness index values of 584.6 for 2012 and 536.4 for 2016[16]. The escalation from 2012 to 2016 thus reduced the TAC by approximately 8%.
- ADEC's calculated cost effectiveness for DSI was $8,269/ton.

5.5.2. Spray Dry Absorption (SDA)

- The ADEC spreadsheet used a unit size of 29.6 megawatts (MW).
- A retrofit factor of 1.0 was used, assuming a retrofit of average difficulty.

- The SDA system was assumed to use lime, and achieve 90% SO2 control efficiency.
- The baseline emissions rate used was 0.2 lb/MMBtu (pounds of SO2 per million British Thermal Units of coal combusted) based on the current emission limit. According to ADEC's calculations, this baseline emissions rate resulted in annual SO2 emissions of 259 tons per year (tpy) and SO2 removed of 233 tpy, assuming 90% control efficiency.
- The calculations used an interest rate of 5%, and an equipment life of 15 years.
- ADEC's cost analysis resulted in TCI of $27,132,570 and annual operating and maintenance costs of $2,983,161[17].
- The Total Annualized Cost was escalated from cost year 2012 (cited as the cost year of the IPM equation) to cost year 2016 (cited as the cost year of the analysis). The escalation used "Composite" cost effectiveness index values of 584.6 for 2012 and 536.4 for 2016. The escalation from 2012 to 2016 thus reduced the TAC by approximately 8%.
- ADEC's calculated cost effectiveness for SDA was $23,061/ton.

5.5.3. Wet Scrubbing, aka Wet Flue Gas Desulfurization (WFGD)

- The ADEC spreadsheet used a unit size of 29.6 megawatts (MW).
- A retrofit factor of 1.0 was used, assuming a retrofit of average difficulty.
- The WFGD system was assumed to use limestone, and achieve 99% SO2 control efficiency.
- The baseline emissions rate used was 0.2 lb/MMBtu (pounds of SO2 per million British Thermal Units of coal combusted) based on the current emission limit. According to ADEC's calculations, this baseline emissions rate resulted in annual SO2 emissions of 259 tons per year (tpy) and SO2 removed of 257 tpy, assuming 99% control efficiency.
- The calculations used an interest rate of 5%, and an equipment life of 15 years.
- ADEC's cost analysis resulted in TCI of $29,487,290 and annual operating and maintenance costs of $3,385,703[18].
- The Total Annualized Cost was escalated from cost year 2012 (cited as the cost year of the IPM equation) to cost year 2016 (cited as the cost year of the analysis). The escalation used "Composite" cost effectiveness index values of 584.6 for 2012 and 536.4 for 2016. The escalation from 2012 to 2016 thus reduced the TAC by approximately 8%.
- ADEC's calculated cost effectiveness for WFGD was $23,343/ton.

5.6. Affordability Analysis

On April 29, 2019, UAF submitted additional information to ADEC in the form of an Economic Infeasibility of SO2 Controls, contending that DSI, the least expensive SO2 control, should not be established because UAF cannot afford the control technology demonstrated to be economically feasible. In order to support their claim, EPA guidance on the matter indicates that the source should make its claim known to the state and support the claim with information regarding the impact of imposing the identified control measure or technology on the following financial indicators to the extent applicable:

- Fixed and variable production costs;
- Product supply and demand elasticity;
- Product prices (cost absorption vs. cost pass-through);
- Expected costs incurred by competitors;
- Company Profits;
- Employment costs;

- Other costs (e.g., for BACM implemented by public sector entities).

Below, is a summary of the financial indicators provided by UAF:

Fixed and variable production costs: Regardless of the exact cost, implementing DSI as SO_2 emissions controls on EU 113 is not financially possible for UAF. UAF is a public institution and an entity of the State of Alaska. On February 13, 2019 Governor Mike Dunleavy released his budget proposal for 2020. The University of Alaska (UA) is facing a proposed budget cut of $134 million, or 41 percent of the state's funding of $327 million, reducing the university's general fund support to $193 million. The cut is on top of state funding cuts that have occurred for four out of the last five years, resulting in program reductions and the loss of more than 1,200 faculty and staff. Under the Governor's spending plan, if his proposed cut is sustained by the legislature, it would be the largest year-over-year reduction in the university's history and would take UA back to 2002 funding levels. These cuts substantially impact UA and harm Alaska's ability to grow the highly trained workforce necessary to be economically competitive with other states.

Product supply and demand elasticity: Product supply and demand elasticity is not an applicable parameter because the steam heat and electricity generated through the use of EU 113 are not sold.

Product prices (cost absorption vs. cost pass-through): Product price is not an applicable parameter because the steam heat and electricity generated through the use of EU 113 are not sold.

Expected costs incurred by competitors: Expected competitor costs is not an applicable parameter because the steam heat and electricity generated through the use of EU 113 are not sold. The UAF CHPP is not competing in the open or semi-open market.

Company Profits: Company profits is not an applicable parameter because UAF is a State of Alaska facility, not a for-profit company.

Employment costs: UAF has requested and has not yet been provided the DEC calculations for the economic analysis of SO_2 controls as discussed above.

Other costs (e.g., for BACM implemented by public sector entities). UAF is a state institution with a budget that is determined by the Legislature. Spending funding on the DSI would cause funds to be diverted from the educational and research mission of the University. Impacts from the lack of funds include fewer staff to provide support services (grounds, maintenance, transportation, human resources, payroll, risk management, safety, fire and police, procurement), reduction in degree programs, further deferred maintenance which will cause deterioration of facilities and roads, inability to replace defunct equipment, and other impacts. The cost in dollars would be the amount of money that would be diverted for operations and maintenance of the DSI annually, plus the cost of construction of the plant and the interest payable on any bonds – the annualized cost of $2,246,238.

6. Summary of the 2020 BACT Submittal – UAF

No additional information regarding the BACT analysis for the UAF emission units was provided within the December 2020 189(d) plan submittal.

7. Summary of 2021-2022 supplemental facility submittals – UAF

EPA Region 10 engaged directly with UAF during 2021-2022 to request additional cost information necessary to justify ADEC's rejection of feasible SO2 controls. UAF has engaged consultant support and is working to develop additional information for submittal to EPA, but no additional information has been submitted to date.

8. EPA Review and Recommendations – UAF CFB Boiler

8.1. Introduction

Although the focus of EPA's BACT review is on the SO2 analysis for the CFB boiler (EU 113), recommendations are included regarding ADEC's PM2.5 and SO2 BACT determinations for other emission units. NOx BACT is expected to be addressed via the precursor analysis.

As described in prior EPA comments, the SO2 BACT analysis submitted for the UAF CFB boiler is fundamentally deficient since the basic cost information necessary to produce a cost effectiveness analysis of at least study-level, or +/-30% accuracy, has not been obtained to date. Due to this lack of adequate cost information, EPA has limited our technical review to the topics detailed below with respect to the CFB boiler.

8.2. Lack of Vendor Cost Estimates

As stated in our 2018 comment letter:

The cost analyses, particularly for SO2 control technologies, must be based on emission unit-specific quotes for capital equipment purchase and installation costs at each facility. These are retrofit projects which must be considered individually in order to obtain reliable study/budget level (+/- 30%) cost estimates which are appropriate to use as the basis for decision making in determining BACT and potentially MSM. EPA believes that control decisions of this magnitude justify the relatively small expense of obtaining site-specific quotes.

To date, only a single site-specific vendor cost estimate has been provided for DSI and SDA on the CFB boiler at UAF, while none have been provided for the two higher performing (in terms of SO2 control efficiency) control technologies (CDS and WFGD). Lacking vendor cost estimates of study-level accuracy, ADEC utilized the IPM spreadsheets.

From EPA's Clean Air Markets Division (CAMD) website[19]:

The Integrated Planning Model (IPM) is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. IPM can be used to evaluate the cost and emissions impacts of proposed policies to limit emissions of sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO2), hydrogen chloride (HCl), and mercury (Hg) from the electric power sector.

As part of the IPM, cost analysis algorithms were developed by Sargent & Lundy under contracts (or sub-contracts) funded by EPA using data obtained from the firm's control installation projects.

The IPM cost model is not intended to be used for site-specific cost analyses, such as those necessary for BACT. It was developed to produce generic costs on a system wide basis. The methodology document[20] prepared by Sargent & Lundy for Dry Sorbent Injection begins with an introductory paragraph which describes the purpose of the cost algorithms for the Integrated Planning Model:

The primary purpose of the cost algorithms is to provide generic order-of-magnitude costs for various air quality control technologies that can be applied to the electric power generating industry on a system-wide basis, not on an individual unit basis.

While these cost algorithms may be valuable for the estimation of costs of controls on individual units if limited vendor data for those units exist, we note that by themselves, the IPM spreadsheets are not a clearly appropriate tool to produce site-specific cost estimates for the CFB boiler at UAF. The IPM spreadsheets represent a cost algorithm that is representative of data from relatively large coal fired energy generating units (EGUs) from across the country. In general, the cost equations are designed for units larger than the CFB boiler[21]. The Sargent and Lundy methodology documents for SDA[22] and WFGD[23] indicate that that smallest units considered during development of the IPM cost equations were around 50-100 MW. All the coal fired boilers subject to BACT under the Fairbanks PM2.5 Serious SIP are smaller than approximately 30 MW, including the CFB boiler at UAF.

Finally, the available site-specific cost information indicates that capital costs calculated using the IPM spreadsheets for the CFB boiler at UAF are overestimates. During review of the 2019 submittal, EPA compiled the available cost information for the three facilities with coal fired boilers in Fairbanks which are subject to BACT for SO2 (Aurora Energy – Chena Power Plant, University of Alaska Fairbanks Power Plant, and Fort Wainwright/Doyon Utilities Combined Heat & Power Plant). In each instance where capital costs (or Total Capital Investment, TCI) calculated using the IPM spreadsheets can be compared with those calculated using a site-specific vendor quote or cost estimate and using the EPA Cost Manual methodology, the IPM spreadsheets as deployed by ADEC or consultants significantly overestimated capital costs.

While the IPM spreadsheet estimates for annual operating and maintenance costs were sometimes similar to estimates made using site-specific vendor information and the EPA Cost Manual methodology, there are other examples where the IPM spreadsheets yielded double or triple the vendor-based estimate of annual costs**.** Thus, given this variance in annual control cost estimates at individual units based on site-specific vendor information and the estimates generated by the IPM spreadsheets, use of these spreadsheets for unit-specific cost calculations should be undertaken with caution.

Cost years for the IPM estimates were 2015 for the Aurora DSI capital costs and 2016 for the Aurora DSI annual costs, as well as the Fort Wainwright and UAF analyses. Vendor estimates were prepared in 2018 (Aurora, DSI and UAF, DSI and SDA) and 2019 (Fort Wainwright, DSI).

Facility	Tech	Cost	IPM Model	Vendor
Aurora	DSI	Capital	$32.5M (40% control)[24]	$20.7M (80% control)[25]
Aurora	DSI	Annual	$3.2M/year[26]	$3.3M/year[27]
Fort Wainwright	DSI	Annual	$11.5M/year[28]	$4.8M/year[29]
UAF	DSI	Capital	$5.2M[30]	$2.5M[31]
UAF	DSI	Annual	$1.3M/year[32]	$1.3M/year[33]
UAF	SDA	Capital	$27.1M[34]	$15.6M[35]
UAF	SDA	Annual	$3M/year[36]	$1M/year[37]

8.3. Evaluation of CDS

As stated in our 2018 comment letter:

The analyses must include evaluation of circulating dry scrubber(CDS) SO2 control technology. This demonstrated technology can achieve SO2 removal rates comparable to wet flue gas desulfurization (FGD) at lower capital and annual costs, and is more amenable to smaller units and retrofits. Modular units are available.

ADEC's BACT analysis submitted in the 2019 Serious SIP does not include an evaluation of CDS, even though it is an available technology for the CFB boiler at UAF. Exclusion of CDS from consideration in the BACT analysis is not in accordance with EPA's top-down BACT guidance; specifically, ADEC did not identify all available controls, per step 1 in the top-down BACT process[38]. In the reference materials submitted with the Serious SIP, no evaluation of CDS is included. No site-specific vendor cost estimates for CDS applied to the UAF CFB boiler have been provided to EPA.

The analysis of CDS submitted to date is therefore insufficient for a BACT determination.

8.4. Equipment Life

As noted, ADEC used 15 years for the equipment life in the cost effectiveness analyses for all three SO2 control technologies. This value is less than EPA recommendations and ADEC did not provide adequate, site-specific, basis for these reduced lifetimes. According to the EPA Cost Manual, the analysis should be based on the expected design or operational life of the control equipment[39]. Ample evidence exists that SO2 control devices operate for 30 years or longer[40].

8.5. Interest Rate

ADEC's cost analyses used 5%, cited as the bank prime interest rate current at the time the analysis was prepared in 2019. Use of the current bank prime rate in this instance is in accordance with the guidance on interest rate choice in the EPA Cost Manual (see pages 15-16 of the Cost Manual methodology chapter) when the affected firm does not offer a firm-specific interest rate to be used in the cost analysis. Since the bank prime rate changes over time, the correct rate to use should align with the dollar year/month of the cost analysis. As of September 16, 2022 the bank prime rate was 5.5%. Current and historic values of the bank prime rate can be accessed on the Federal Reserve website[41].

8.6. Technical Feasibility

As discussed above, the 2019 Serious SIP BACT analyses prepared by ADEC determined that the listed SO2 control technologies are technically feasible for the CFB boiler at UAF[42]. Of the four key SO2 control technologies identified by EPA for the CFB boiler, ADEC's BACT analysis included DSI, SDA, and WFGD. CDS was not included in ADEC's BACT analysis, nor has it been thoroughly evaluated, as discussed above.

In addition to the necessity for study-level, +/- 30% accuracy cost information as discussed in the EPA Cost Manual, more rigorous evaluation of the technical feasibility of all four control technologies is necessary for the CFB boiler. In the top-down BACT process, a control technology must be determined to be technically feasible in order to proceed to the cost analysis step in the process. For non-attainment BACT, all control technologies are deemed technologically and economically feasible unless demonstrated otherwise by the state. ADEC's BACT analysis and earlier submittals by UAF only contain limited consideration of installation considerations resulting from the close proximity of the CFB boiler and the existing baghouse. The close proximity must be considered in detail in order to evaluate the feasibility of routing the exhaust ducting from the boiler to any new SO2 control vessel that must be placed upstream of the baghouse. The proximity also has implications for the SO2 control efficiency achievable by DSI.

The materials submitted to date do not adequately evaluate the technical feasibility of installation of these control technologies on the CFB boiler at UAF. Control equipment vendors should be contacted to review the site conditions and prepare site-specific evaluations of installation considerations. A minimum of three vendors for each control technology is recommended in order to ensure the information relied upon for decision making is reliable and all installation options are considered.

8.7. Affordability Analysis

The affordability analysis information provided by UAF does address several of the indicators included in the EPA guidance on the issue. UAF is not a privately owned entity that operates in a competitive power market, and thus a number of the affordability analysis indicators may not be the most useful measures of UAF's ability to afford BACT controls. However, the statements regarding lack of funds due to reductions in spending by the State of Alaska have not been justified by further information on spending allocations in the state budget specific to UAF. These statements on UAF's positions regarding its ability to afford fixed and variable costs of potential BACT controls and the impact of other costs (indicators 1 and 7, respectively) must be justified further in writing, and EPA at this point has not received any such written justification.

8.8. Recommendations

8.8.1. CFB Boiler SO2 BACT

Based on review of the information submitted, we recommend disapproval of the SO2 BACT determination for the UAF CFB boiler. ADEC has not adequately demonstrated that SO2 controls with higher control efficiency are either technologically or economically infeasible. Therefore ADEC either needs to adopt and implement the best performing control technology as SO2 BACT or revise its SIP to include technologic or economic infeasibility demonstrations consistent with this analysis.

Preparation of a revised BACT analysis based on +/- 30%, study-level cost information could be expected to allow a detailed agency review and a greater likelihood of an approvable BACT determination by the agency.

8.8.2. CFB Boiler PM2.5 BACT

The existing baghouse represents the top level control device for filterable PM2.5 from the CFB boiler, therefore approval of ADEC's BACT determination is recommended.

9. EPA Review and Recommendations – Other Emission Units

9.1. Diesel-Fired Engines

For EUs 24, 28, and 29 the limits on annual hours of operation of 100 hrs/year or less will likely result in add-on control equipment such as diesel particulate filters (DPF) being cost prohibitive, therefore approval of ADEC's PM2.5 BACT determination for EUs 24, 28, and 29 is recommended.

For EU 8, the limit on annual hours of non-emergency operation of 100 hrs/year and the shared limit on NOx emissions of 40 tons/year with EU 4 will likely result in add-on control equipment such as diesel particulate filters (DPF) being cost prohibitive, therefore approval of ADEC's PM2.5 BACT determination for EU 8 is recommended.

For the three remaining diesel engines, ADEC's SIP did not include hourly limits for EUs 23 and 26, and limited operation of EU 27 to 4,380 hours/year. No cost analysis was conducted for EUs 23 and 26. With no limits on hourly operation, DPF may be cost effective. Disapproval of ADEC's PM2.5 BACT determination for EUs 23 and 26 is therefore recommended.

ADEC did submit a cost effectiveness analysis for DPF for EU 27 as discussed above. EPA's review indicated that the cost analysis was not conducted using the correct baseline emission rate. EPA has prepared revised calculations based on operation of EU 27 at ADEC's BACT PM2.5 emission limit of 0.15 grams per horsepower-hour for 4,380 hours/year, with a resulting DPF cost effectiveness of $8,019/ton[43]. DPF is therefore recommended as a cost effective control technology. Disapproval of ADEC's PM2.5 BACT determination for EU 27 is therefore recommended.

For all diesel-fired engines, ADEC's BACT determination requiring combustion of only ULSD represents the top control option for reducing SO2 emissions. ADEC's summary of the BACT determination within Chapter III.D.7.07 Control Strategies[44] specifies ULSD as the only fuel to be combusted in the diesel-fired engines on pages 94-95, and includes a finding on page 101 requiring UAF to submit a permit application to implement this limit starting on June 9, 2021. Approval of ADEC's SO2 BACT determination for the diesel-fired engines is recommended.

9.2. Diesel-Fired Boilers

For the mid-sized diesel-fired boilers (EUs 3 and 4), EU 4 is subject to the combined annual NOx limit of 40 tons/year with the large diesel-fired engine, EU 8. This effectively limits the operation of EU 4, and likely results in any add-on control equipment for PM2.5 being cost prohibitive. EU 3 is not subject to any operational limitations. Based on the consultation with the boiler manufacturer and the fact that few if any diesel boilers are operated with add-on PM2.5 control equipment, ADEC determined that all add-on control devices are technically infeasible. The technical infeasibility determination is questionable based on the inherent technical flexibility of venturi and other scrubbing technologies, which could likely operate successfully on a diesel fired boiler if properly designed. Additionally, wet scrubbers were considered technically feasible for the smaller diesel-fired boilers (EUs 19-21), so it is not clear why they would then be technically infeasible for the larger boilers EUs 3 and 4. EPA has prepared a cost effectiveness analysis for Boiler 3 since no operational limitations were proposed. EPA's cost effectiveness analysis indicates that wet scrubbing for EU 3 is not likely to be cost effective at $53,921/ton[45]. Based on this information, approval of ADEC's PM2.5 BACT determination for EUs 3 and 4 is recommended.

The UAF cost effectiveness analysis for a scrubber installed on the small diesel-fired boilers (EUs 19-21) is discussed above. EPA's review indicated that the cost analysis was not conducted using the correct baseline emission rate, interest rate, and equipment life. EPA has prepared revised calculations based on combined operation of the smaller boilers at ADEC's BACT PM2.5 emission limit of 0.012 lb/MMBtu for 19,650 hours/year, 30-year equipment life, an interest rate of 5% to reflect the bank prime rate at the time of the SIP submittal, and including direct and indirect installation capital costs according to the EPA Control Cost Manual with a resulting scrubber cost effectiveness of $68,734/ton[46]. EPA's cost effectiveness analysis indicates that a wet scrubber for EUs 19-21 are not likely to be cost effective. Based on this information, approval of ADEC's PM2.5 BACT determination for EUs 19-21 is recommended.

For all diesel-fired boilers, ADEC's BACT determination requiring combustion of only ULSD (or natural gas in the case of EU 4) represents the top control option for reducing SO2 emissions. ADEC's summary of the BACT determination within Chapter III.D.7.07 Control Strategies[47] specifies ULSD as the only fuel to be combusted in the diesel-fired boilers on pages 93-94. However, at the top of page 101, ADEC includes findings requiring UAF to submit permit applications such that ULSD is not required until October 1, 2023. The ADEC Serious SIP BACT analysis includes no basis for delaying the switch to ULSD, therefore approval of combustion of only ULSD as SO2 BACT is recommended, but disapproval is recommended for the delayed fuel switch.

9.3. Pathological Waste Incinerator

Given the operational limit of combusting not more than 109 tons of waste per year ADEC's determination that add-on control equipment is not cost effective is reasonable, assuming the incinerator complies with the BACT PM2.5 emission rate of 4.67 pounds of PM2.5 per ton of waste burned. Given that this unit operates uncontrolled with respect to PM2.5 emissions, initial and periodic emission testing using EPA Reference Test Methods 5 and 202 for filterable and condensable PM (at least 3, one-hour runs) is recommended to ensure the incinerator complies with the emission limit. Approval of ADEC's PM2.5 BACT determination for the incinerator is recommended with these emission testing requirements.

For the incinerator, ADEC's BACT determination requiring combustion of only ULSD represents the top control option for reducing SO2 emissions. ADEC's summary of the BACT determination within Chapter III.D.7.07 Control Strategies[48] specifies ULSD as the only fuel to be combusted in the diesel-fired boilers on pages 95-96. Approval of ADEC's SO2 BACT determination for the incinerator is recommended.

9.4. Material Handling Units

For the material handling units where ADEC determined BACT to constitute enclosure and routing to a fabric filter (EUs 105, 107, 109, 110, 114 & 128-130), this represents the top control option for reducing PM2.5 emissions. Initial compliance testing is required. Appropriate monitoring, recordkeeping, and reporting (MR&R) conditions are recommended to ensure enclosures and ventilation equipment are properly designed to achieve effective capture of PM2.5 emissions and that no visible emissions escape from the capture systems. Approval of ADEC's PM2.5 BACT determination for these units is recommended, with appropriate MR&R conditions.

For EU 111, ash loadout to truck, ADEC's BACT determination requires enclosure only. The UAF BACT analysis[49] includes additional detail, explaining that ash loadout occurs inside a building with the doors closed. Approval of ADEC's PM2.5 BACT determination for EU 111 is recommended, with the operational requirement that the building doors remain closed at all times that ash loading is occurring. Appropriate MR&R conditions should be included to ensure no visible emissions escape the building.

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[1] See "20180521 Spring 2018 ADEC Information Release, Transmittal Letter May 21 2018 signed.pdf" and the attached comments "20180521 Spring 2018 ADEC Information Release, Final Comment Letter.pdf".

[2] See "20190719 Fairbanks Serious Area Plan Comments, 7.19.19 letter.pdf"

[3] "Alaska Department of Environmental Conservation, Amendments to State Air Quality Control Plan, Vol. II: III.D.7.7 Control Strategies, Adopted November 19, 2019", submitted to EPA on December 13, 2019, document name "Chapter III.D.7.07 Control Strategies.pdf".

[4] For purposes of ADEC's BACT analysis, control technologies already in place or that are part of the emission unit design are considered 0% control.

[5] See "2017-02-08 UAF_BACT_PM2.5_Tables_4-X (UAF).xlsx", "4-6 – 27 – TCI" and "4-6 – 27 – CE" Tabs.

[6] November 11, 2015 email from Erick Pomrenke of NC Power Systems to Lain Pacini of Stanley Consultants. This document is found in the State of Alaska Serious SIP Submittal from December 2019, beginning on pdf page 283 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".

[7] Voluntary BACT Analysis for the Serious PM2.5 Non-Attainment Area Classification prepared for University of Alaska Fairbanks by SLR International, dated January, 2017. This report is included in the State of Alaska Serious SIP Submittal from December 2019, and the section addressing the technical feasibility of PM2.5 controls on EUs 3 and 4 begins on pdf page 153 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".

[8] See "2017-02-08 UAF_BACT_PM2.5_Tables_4-X (UAF).xlsx", "4-4 – 19-21 – TCI" and "4-5 – 19-21 – CE" Tabs.

[9] November 4, 2015 email from Troy Nibert of Proctor Sales, Inc. to Cindy Stevenson of Stanley Consultants. This document is found in the State of Alaska Serious SIP Submittal from December 2019, beginning on pdf page 277 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".

[10] See "2017-02-08 UAF_BACT_PM2.5_Tables_4-X (UAF).xlsx", "4-8 – 9A – TCI" and "4-9 – 9A – CE" Tabs.

[11] Email chain between Cindy Stevenson of Stanley Consultants and Dean Robbins of Thermtec, Inc. between October 27 and November 4, 2015. The emails are found in the State of Alaska Serious SIP Submittal from December 2019, beginning on pdf page 298 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".

[12] See "2019-11-13 UAF SO2 Controls Economic Analyses (ADEC).xlsx"

[13] February 1, 2016 email from David Novogoratz of The Babcock & Wilcox Company to John Solan of Stanley Consultants. This document is found in the State of Alaska Serious SIP Submittal from December 2019, beginning on pdf page 243 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".

[14] "Total Project Cost" in the IPM spreadsheets, which is analogous to Total Capital Investment (TCI) as used by the EPA Cost Manual.

[15] EPA calculated this annual O&M cost by subtracting annual capital recovery cost (escalated to dollar year 2016) from the "Total Annualized Operating Costs (2016 $)" calculated by ADEC. For calculations, see "UAF calcs EPA-TSD.xlsx", "DSI-ADEC 2019 EPA Edits" Tab.

[16] ADEC's "composite" cost index values closely mirror the 2012 and 2016 values for the Chemical Engineering Plant Cost Index (CEPCI), which were approximately 585 in 2012 and 541 in 2016.

[17] EPA calculated this annual O&M cost by subtracting annual capital recovery cost (escalated to dollar year 2016) from the "Total Annualized Operating Costs (2016 $)" calculated by ADEC. For calculations, see "UAF calcs EPA-TSD.xlsx", "SDA-ADEC 2019 EPA Edits" Tab.

[18] EPA calculated this annual O&M cost by subtracting annual capital recovery cost (escalated to dollar year 2016) from the "Total Annualized Operating Costs (2016 $)" calculated by ADEC. For calculations, see "UAF calcs EPA-TSD.xlsx", "WFGD-ADEC 2019 EPA Edits" Tab.

[19] https://www.epa.gov/airmarkets/epas-power-sector-modeling-platform-v6-using-ipm-summer-2021-reference-case

[20] "IPM Model – Updates to Cost and Performance for APC Technologies; Dry Sorbent Injection for SO2/HCl Control Cost Development Methodology", Sargent & Lundy, LLC., April 2017. Available at: https://www.epa.gov/system/files/documents/2021-09/attachment_5-5_dsi_cost_development_methodology.pdf

[21] May 14, 2020 email from George Bowker of EPA Clean Air Markets Division (CAMD) to Zach Hedgpeth of EPA Region 10.

[22] "IPM Model – Updates to Cost and Performance for APC Technologies; SDA FGD Cost Development Methodology", Sargent & Lundy, LLC., January 2017. Available at: https://www.epa.gov/system/files/documents/2021-09/attachment_5-2_sda_fgd_cost_development_methodology.pdf

[23] "IPM Model – Updates to Cost and Performance for APC Technologies; Wet FGD Cost Development Methodology", Sargent & Lundy, LLC., January 2017. Available at: https://www.epa.gov/system/files/documents/2021-09/attachment_5-1_wet_fgd_cost_development_methodology.pdf

[24] "Addendum to Best Available Control Technology Analysis, Chena Power Plant", ERM, December 2017. For IPM capital costs, see "Appendix III.D.7.07 Control Strategies Part 5.pdf", pg 129 (ERM report starts on pg 93). Total Project Cost (TPC) = $32,500,898.

[25] "Preliminary Opinion of Probable Cost for Addition of Dry Sorbent Injection", Stanley Consultants, Inc., October 30, 2018. See "Appendix III.D.7.07 Control Strategies Part 5.pdf", pg 200 (Stanley report starts on pg 196). For calculations, see "Aurora calcs EPA-TSD.xlsx", "DSI-Stanley 2019-SBC" Tab, Total Project Cost (TPC) = $20,682,000.

[26] "2019-11-13 Chena SO2 Controls Economic Analyses (ADEC).xlsx". For calculation of IPM annual O&M costs, see "Aurora calcs EPA-TSD.xlsx", "DSI-ADEC 2019-EPA Edits" Tab, Total Annual Costs (2016 dollars) is calculated by subtracting cost recovery from Total Annualized Costs = $3,235,623/year.

[27] For calculation of Total Annual Cost, see "Aurora calcs EPA-TSD.xlsx", "DSI-Stanley 2019-SBC" Tab, Total Annual Cost of $3,296,564 is calculated based on info from BACT Process Systems, a Vendor, EPA Cost Manual factors, and actual sorbent costs from Eielson AFB.

[28] See "FTWW calcs EPA-TSD.xlsx", "DSI-ADEC 2019 EPA Edits" Tab. Total Annual Costs, cost year 2016 (subtracting cost recovery) = $11,466,810.

[29] For calculation of Total Annual Cost, see "FTWW calcs EPA-TSD.xlsx", "DSI-Vendor 2019-SBC" Tab, Total Annual Cost of $4,796,412 is calculated based on info from a Vendor, EPA Cost Manual factors, and actual sorbent costs from Eielson AFB. Used higher of SBC or Trona total annual cost from Vendor.

[30] See "2019-11-13 UAF SO2 Controls Economic Analyses (ADEC).xlsx", "Dry Sorbent Injection" Tab. For capital cost, TPC = $5,192,915.

[31] See "2018-11-20 UAF_BACT_SO2_Tables_5-X (UAF).xlsx", "5-6 - EU ID 113 - DSI TCI" Tab. Based on proposal from Babcock & Wilcox. TCI = $2,535,000.

[32] See "UAF calcs EPA-TSD.xlsx", "DSI-ADEC 2019 EPA Edits" Tab. Total Annual Costs (2016 dollars) is calculated by subtracting cost recovery from Total Annualized Costs: $1,256,331/year.

[33] See "UAF calcs EPA-TSD.xlsx", "EU 113 DSI CE EPA Edits" Tab. For annual O&M, add Administrative and Insurance costs to TDAC = $1,311,210/year.

[34] See "2019-11-13 UAF SO2 Controls Economic Analyses (ADEC).xlsx", "Spray Dry Absorber" Tab. For capital cost, TPC = $27,132,570.

[35] See "2018-11-20 UAF_BACT_SO2_Tables_5-X (UAF).xlsx", "5-4 - EU ID 113 - SDA TCI" Tab. Based on proposal from Babcock & Wilcox. TCI = $15,600,000.

[36] See "UAF calcs EPA-TSD.xlsx", "SDA-ADEC 2019 EPA Edits" Tab. Total Annual Costs (2016 dollars) is calculated by subtracting cost recovery from Total Annualized Costs: $2,983,161/year.

[37] See "UAF calcs EPA-TSD.xlsx", "EU 113 SDA CE EPA Edits" Tab. For annual O&M, add Administrative and Insurance costs to TDAC = $1,049,664/year.

[38] "Draft October 1990 New Source Review Workshop Manual". See Step 1 discussion starting on page 80 of the pdf. The document is available at https://www.epa.gov/sites/default/files/2015-07/documents/1990wman.pdf
[39] EPA Air Pollution Control Cost Manual, Chapter 2 Cost Estimation: Concepts and Methodology, USEPA, November 2017. Available at: https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf See page 22.
[40] EPA Air Pollution Control Cost Manual, Section 5 SO2 and Acid Gas Controls, USEPA, April 2021. Available at: https://www.epa.gov/sites/default/files/2021-05/documents/wet_and_dry_scrubbers_section_5_chapter_1_control_cost_manual_7th_edition.pdf See page 1-8 and elsewhere in the chapter.
[41] https://www.federalreserve.gov/releases/h15/ (go to bank prime rate in the table).
[42] "Alaska Department of Environmental Conservation, Amendments to State Air Quality Control Plan, Vol. II: III.D.7.7 Control Strategies, Adopted November 19, 2019", submitted to EPA on December 13, 2019, document name "Chapter III.D.7.07 Control Strategies.pdf". See Section 7.7.8.6.3 starting on pdf page 92 of 106.
[43] See "UAF calcs EPA-TSD.xlsx", "EU 27 DPF CE EPA Edits" Tab.
[44] "Alaska Department of Environmental Conservation, Amendments to State Air Quality Control Plan, Vol. II: III.D.7.7 Control Strategies, Adopted November 19, 2019", submitted to EPA on December 13, 2019, document name "Chapter III.D.7.07 Control Strategies.pdf".
[45] See "UAF calcs EPA-TSD.xlsx", "EU 3 Scrubber" Tab.
[46] See "UAF calcs EPA-TSD.xlsx", "4-4 - 19-21 - TCI EPA Edits" and "4-5 - 19-21 - CE EPA Edits" Tabs.
[47] "Alaska Department of Environmental Conservation, Amendments to State Air Quality Control Plan, Vol. II: III.D.7.7 Control Strategies, Adopted November 19, 2019", submitted to EPA on December 13, 2019, document name "Chapter III.D.7.07 Control Strategies.pdf".
[48] "Alaska Department of Environmental Conservation, Amendments to State Air Quality Control Plan, Vol. II: III.D.7.7 Control Strategies, Adopted November 19, 2019", submitted to EPA on December 13, 2019, document name "Chapter III.D.7.07 Control Strategies.pdf".
[49] Voluntary BACT Analysis for the Serious PM2.5 Non-Attainment Area Classification prepared for University of Alaska Fairbanks by SLR International, dated January, 2017. This report is included in the State of Alaska Serious SIP Submittal from December 2019, and the section addressing EU 111 occurs on pdf page 149 of "Appendix III.D.7.07 Control Strategies Part 3.pdf".