Appendix J: Regional Haze Four-Factor Analysis,
Maui Electric Light Company, Ltd.
Maalaea Generating Station

Initial Four – Factor Analysis

KARIN KIMURA
Director
Environmental Division

April 22, 2020

SENT VIA EMAIL [redacted]

Ms. Marianne Rossio, P.E.
Manager, Clean Air Branch
State of Hawaiʻi Department of Health
2827 Waimano Home Road
Hale Ola Building, Room 130
Pearl City, Hawaiʻi 96782

Subject: Regional Haze Four-Factor Analyses
Maalaea Generating Station, Maui Electric Company, Ltd.

Dear Ms. Rossio:

Hawaiian Electric[1] submits the enclosed "Regional Haze Four-Factor Analysis" report for the Maalaea Generating Station (Maalaea) as requested by the letter dated September 11, 2019 from the Department of Health Clean Air Branch (DOH).

Hawaiian Electric submitted the four-factor analyses for the Kanoelehua-Hill, Puna, and Kahului Generating Stations on March 31, 2020 and for the Kahe and Waiau Generating Stations on April 6, 2020. In the April 6, 2020 cover letter to DOH, Hawaiian Electric notified DOH of unforeseen delays in obtaining information for one of the potential emission controls for Maalaea. To avoid further delay, Hawaiian Electric submits the four-factor analysis for Maalaea and will provide the remaining assessments to DOH when the information becomes available.

Should you have any questions or concerns, please contact Sharon Peterson at [redacted] or [redacted]

Sincerely,

Enclosures: Regional Haze Four-Factor Analysis Report – Maalaea

Ec w/ Encl: Mike Madsen, Hawaiʻi Department of Health (Michael.madsen@doh.hawaii.gov)
Scott Takamoto, Hawaiʻi Department of Health (clayton.takamoto@doh.hawaii.gov)

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[1] "Hawaiian Electric" or the "Company" refers to Hawaiian Electric Company, Inc. (or "HE"), Hawaiʻi Electric Light Company, Inc. (or "HL") and/or Maui Electric Company, Limited (or "ME"). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 290, 2019 in the Business Registration Division of the DCCA.

REGIONAL HAZE FOUR-FACTOR ANALYSIS
Maalaea Generating Station

Hawaiian Electric

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April 2020

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1. EXECUTIVE SUMMARY

The State of Hawaiʻi has two Class I areas (National Parks) that trigger compliance with the Regional Haze Rule (RHR): Hawaiʻi's Mandatory Federal Class I Areas are Haleakalā National Park on Maui and Hawaiʻi Volcanoes National Park on the Hawaiʻi Island. This report documents the results of the Regional Haze Rule (RHR) second planning period four-factor analysis conducted by Trinity Consultants (Trinity) on behalf of Hawaiian Electric[1] for the generating units at the Maalaea Generating Station (Maalaea). Maalaea contains:

- Five 2.5 megawatt (MW) diesel engine generators (M1, M2, M3, X1, and X2) currently firing ultra-low sulfur diesel (ULSD);
- Six 5.9 MW diesel engine generators (M4, M5, M6, M7, M8, and M9) currently firing diesel with a maximum sulfur content of 0.4 percent by weight;
- Four 12.5 MW diesel engine generators (M10, M11, M12, and M13) currently firing diesel with a maximum sulfur content of 0.4 percent by weight; and
- Four 20 MW combustion turbine generators (M14, M16, M17, and M19) currently firing diesel with a maximum sulfur content of 0.4 percent by weight.

Also, Appendix B and Appendix C contain analyses performed by AECOM Technical Services, Inc. (AECOM) of a fifth factor that includes a review of visibility impacts.

This report addresses the options that could be considered that have that have the potential to lower emissions. The results of the four-factor analysis herein are consistent with the conclusions reached for the first planning period Best Available Retrofit Technology (BART) five-factor analysis for Kahului and Kanoelehua-Hill. Other long-term emission reduction strategies, such as those included as part of Hawaiʻi's Renewable Portfolio Standards (RPS), are viable alternatives to emission reductions from add-on controls and changes in the method of operations.

Hawaiian Electric and AECOM met with the Department of Health (DOH) on February 12, 2020 to present special circumstances that apply in Hawaiʻi that should be given consideration in the development of the Hawaiʻi Regional Haze State Implementation Plan (SIP). Significant among those circumstances is Hawaiʻi's Statutory RPS which have put the state on a timetable to accomplish the same goals as the RHR twenty (20) years before the actual Regional Haze 2064 target date. These same issues were addressed by the EPA in the Federal Implementation Plan (FIP) and the DOH in its Progress Report[2] that was approved by the EPA effective on September 11, 2019. These special considerations are discussed further in Appendix B and Appendix C to this report.

Based on the four-factor analysis, and the materials set forth in the appendices, Hawaiian Electric does not propose any emissions reduction measures in addition to its RPS program to meet the RHR requirements.

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[1] Hawaiian Electric" or the "Company" refers to Hawaiian Electric Company, Inc. (or "HE"), Hawaiʻi Electric Light Company, Inc. (or "HL") and/or Maui Electric Company, Limited (or "ME"). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

[2] 5-Year Regional Haze Progress Report for Federal Implementation Plan, Hawaiʻi State Department of Health, October 2017, EPA-R09-OAR-2018-0744-0004.

2. BACKGROUND AND ADDITIONAL FACTORS

2.1. REGIONAL HAZE RULE BACKGROUND

In the 1977 amendments to the federal Clean Air Act (CAA), the U.S. Congress set a nation-wide goal to restore national parks and wilderness areas to natural visibility conditions by remedying existing, anthropogenic visibility impairment and preventing future impairments. On July 1, 1999, the EPA published the final RHR (40 CFR Part 51, Subpart P). The objective of the RHR is to restore visibility to natural conditions in 156 specific areas across the United States, known as Federal Class I areas. The CAA defines Class I areas as certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres)[3], and international parks that were in existence on August 7, 1977.

The RHR requires states to set goals that provide for reasonable progress towards achieving natural visibility conditions for each Class I area in their jurisdiction. In establishing a reasonable progress goal for a Class I area, each state must:

> *(A) Consider the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected sources, and include a demonstration showing how these factors were taken into consideration in selecting the goal. 40 CFR 51. 308(d)(1)(i)(A).* This is known as a four-factor analysis.
>
> *(B) Analyze and determine the rate of progress needed to attain natural visibility conditions by the year 2064. To calculate this rate of progress, the State must compare baseline visibility conditions to natural visibility conditions in the mandatory Federal Class I area and determine the uniform rate of visibility improvement (measured in deciviews) that would need to be maintained during each implementation period in order to attain natural visibility conditions by 2064. In establishing the reasonable progress goal, the State must consider the uniform rate of improvement in visibility and the emission reduction. 40 CFR 51. 308(d)(1)(i)(B).* The uniform rate of progress or improvement is sometimes referred to as the glidepath and is part of the state's Long Term Strategy (LTS).

During the first implementation period the EPA issued a FIP (77 FR 61478, October 9, 2012; see also *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii Air Division* U.S. EPA Region 9, May 14, 2012) which determined for the first planning period that NO_X was not contributing to regional haze significantly as to require control measures, and that the Oahu sources were not significantly contributing to regional haze. Additionally, as part of the EPA's decision with respect to BART controls, the EPA took into account that controls would result in "unduly increasing electricity rates in Hawaii." (see 77 FR 31707, May 29, 2012).

The control measures that were imposed during the first RHR implementation period established an emissions cap of 3,550 tons of SO_2 per year from the fuel oil-fired boilers at Hawaiʻi Electric Light's Hill, Shipman and Puna generating stations, beginning in January 1, 2018, at an estimated cost of 7.9 million dollars per year. According to the FIP, this represents a reduction of 1,400 tons per year from the total projected 2018 annual emissions of SO_2 from these facilities. This control measure, in conjunction with SO_2 and NO_X emissions control requirements that are already in place, was found to ensure that reasonable progress is made during this first planning period toward the national goal of no anthropogenic visibility impairment by 2064 at Hawaiʻi's two Class I areas.

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[3] The Class I areas in the state of Hawaiʻi include the Hawaiʻi Volcanoes National Park on the Hawaiʻi Island, and Haleakalā National Park on Maui.

The second implementation planning period (2019-2028) for the national regional haze efforts is currently underway. The EPA's *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period* (SIP Guidance)[4] provides guidance for the development of the implementation plans. There are a few key distinctions from the processes that took place during the first planning period (2004-2018). Most notably, the second planning period analysis distinguishes between natural (or "biogenic") and manmade (or "anthropogenic") sources of emissions. The EPA's *Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program* (Visibility Guidance)[5] provides guidance to states on methods for selecting the twenty (20) percent most impaired days to track visibility and determining natural visibility conditions. The approach described in this guidance document does not expressly attempt to account for haze formed from natural volcanic emissions; however, the 2017 RHR defines visibility impairment or anthropogenic visibility impairment as:

> *any humanly perceptible difference due to air pollution from anthropogenic sources between actual visibility and natural visibility on one or more days. Because natural visibility can only be estimated or inferred, visibility impairment also is estimated or inferred rather than directly measured.*

Specifically, the EPA's Visibility Guidance states that although they did not attempt to account for haze formed by natural volcanic emissions:

> *We encourage states with Class I areas affected by volcanic emissions to work with their EPA Regional office to determine an appropriate approach for determining which days are the 20 percent most anthropogenically impaired days.*

In the *5-Year Regional Haze Progress Report for Federal Implementation Plan,*[6] the DOH acknowledges the impact of SO_2 from the Kilauea volcano with the following statement:

> *A majority of the visibility degradation is due to the ongoing release of SO_2 from Kilauea volcano with emissions that vary by hundreds of thousands of tons from one year to another. Visibility improvement from significant reductions in Maui and Hawaii Island point source SO_2 is obscured by sulfate from natural volcanic SO_2 that overwhelms sulfate from anthropogenic SO_2 sources.*

Step 1 of the EPA's SIP Guidance is to identify the twenty (20) percent most anthropogenically impaired days and the twenty (20) percent clearest days and determine baseline, current, and natural visibility conditions for each Class I area within the state (40 CFR 51.308(f)(1)). Hawaiian Electric has concerns that this key step may not be accounted for during the second implementation planning period and the development of Hawaiʻi's RHR SIP. The identification of the twenty (20) percent most impaired days sets the foundation for identifying any needed emission reductions.

Pursuant to 40 CFR 51.308(d)(3)(iv), the states are responsible for identifying the sources that contribute to the most impaired days in the Class I areas. To accomplish this, the Western Regional Air Partnership (WRAP), with Ramboll US Corporation, reviewed the 2014 National Emissions Inventory (NEI) and assessed each facility's impact on visibility in Class I areas with a "Q/d" analysis, where "Q" is the magnitude of emissions that impact ambient visibility and "d" is the distance of a facility to a Class I area. The WRAP Guidance itself states that the EPA has concerns over only relying on the Q/d method for screening sources. The EPA points out that the Q/d metric is only a rough indicator of actual visibility

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[4] US EPA Memorandum, "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period August 20, 2019, https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

[5] US EPA Memorandum, "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program", Dec. 20, 2019, Page 6 https://www.epa.gov/sites/production/files/2018-12/documents/technical_guidance_tracking_visibility_progress.pdf.

[6] 5-Year Regional Haze Progress Report for Federal Implementation Plan, Hawaiʻi State Department of Health, October 2017, EPA-R09-OAR-2018-0744-0004.

impact because it does not consider transport direction/pathway and dispersion and photochemical processes. To address the EPA's concern, the WRAP subcommittee recommends a second step, application of the weighted emissions potential analysis (WEP), which has not been done.[7] On September 11, 2019, the DOH informed Hawaiian Electric that its Maalaea Generating Station (Maalaea), among others, was identified, based on the Q/d analysis, as one of the sources potentially contributing to regional haze at the Haleakalā National Park and Volcanoes National Park. This report responds to the DOH September 2019 request to Hawaiian Electric to submit a four-factor analysis for Maalaea.

The SIP Guidance requires that the selection of sources and controls necessary to make reasonable progress must, in addition to the statutory four factors (cost, remaining useful life, etc.), also consider the five required factors listed in 40 CFR section 51.308(f)(2)(iv), and other factors that are reasonable to consider.[8] These additional factors include consideration of emissions reductions due to ongoing air pollution control programs and the anticipated net effect on visibility due to projected changes in source emissions. The Hawaiian Electric and AECOM prepared summary, included in Section 2.2, describes special circumstances applicable in Hawaiʻi that should be considered during the development of the Hawaiʻi Regional Haze SIP.

2.2. ADDITIONAL FACTORS

Hawaiian Electric and AECOM met with the DOH on February 12, 2020 to present special circumstances applicable in Hawaiʻi that should be considered during the development of the Hawaiʻi Regional Haze SIP. Significant among those circumstances is Hawaiʻi's Statutory RPS which have put the state on a timetable to accomplish the same goals as the RHR twenty years before the Regional Haze 2064 target date. These same issues were addressed by the EPA in the FIP and the DOH in its Progress Report that was approved by the EPA, effective on September 11, 2019. These special considerations are discussed further in Appendix B and Appendix C to this report and summarized in the following sections.

2.2.1. Lack of Contribution to Visibility Impairment Due to Prevailing Winds

As noted above, the DOH did not consider actual contribution to visibility impairment when selecting sources for the Four-Factor Analysis, but this is a critical factor in establishing realistic reasonable progress goals for Class I areas. The EPA's FIP for Hawaiʻi for the First Decadal Review (77 FR 61478, October 9, 2012) has already acknowledged the predominant trade winds in Hawaiʻi and thus, did not require controls on upwind sources (i.e., sources on Oahu and Maui).

The wind rose for the Kahului airport on Maui shows that the wind is almost always from the northeast and rarely blows from the west or northwest, the directions that could cause emissions from Maalaea to blow toward either of Hawaiʻi's Class I areas. The Kahului airport wind rose plot is provided below as Figure 2-1. Based on the infrequent wind blows from Maalaea toward either of Hawaiʻi's Class I areas, it is unlikely that the facility's emissions impact visibility at either Haleakalā National Park or Volcanoes National Park. Therefore, when balancing retrofit costs and visibility improvements, the DOH should consider the fact that emissions from this facility are unlikely to contribute to regional haze at Haleakalā National Park and Volcanoes National Park and as such additional emission reduction measures will have no impact on a showing of further reasonable progress.

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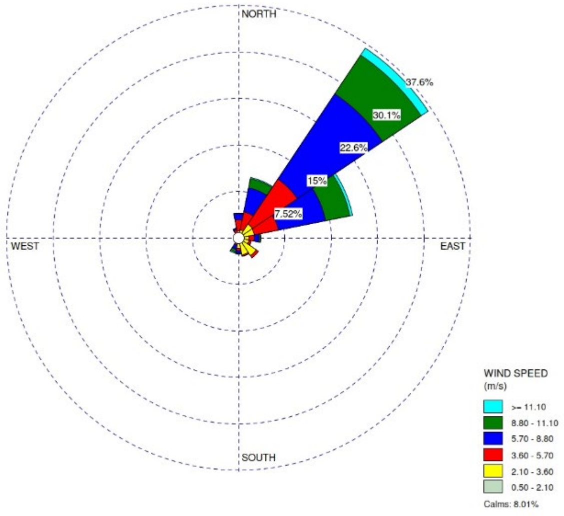
[7] WRAP Reasonable Progress Source Identification and Analysis Protocol for Second 10-year Regional Haze State Implementation Plans, dated February 27, 2019 (https://www.wrapair2.org/pdf/final%20WRAP%20Reasonable%20Progress%20Source%20Identification%20and%20Analysis%20Protocol-Feb27-2019.pdf).

[8] US EPA Memorandum, "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program", December 20, 2018, pp. 9, 21, C-1.

Figure 2-1. Kahului Wind Rose (2015 – 2019) Predominant Wind from the Northeast



2.2.2. Lack of Contribution to Visibility Impairment Due to Warm Weather Conditions

The potential for the formation of haze due to NO_X emissions is very low in Hawai'i because of the warm weather conditions year round. Nitrate haze composition analyses for the Haleakalā and Hawaiʻi Volcanoes National Parks from the IMPROVE web site are included in Appendix B to this report. The data for both national parks shows that the contribution of nitrates to haze is very low. It is low as a percentage of the total haze composition, but it is also low as an absolute value for light extinction (visibility impairment). The minimal impact of nitrate haze is clearly illustrated in the Hawaiʻi Volcanoes National Parks monitoring data and is much lower than found at many monitors in other Class I areas around the country. This is in large part due to the unique chemistry of nitrate haze which is discussed further in Appendix B to this report.

Due to the low haze impact of NO_X, the DOH should not consider NO_X controls for the Second Decadal Review for Maalaea. A similar conclusion was reached during the First Decadal Review, for which the EPA did not consider NO_X controls to be material.

2.2.3. Contribution to Visibility Impairment from Volcanic Activity

Volcanic activity on the Hawaiʻi Island represents a unique challenge to understanding haze in Hawaiʻi Class I areas. The Kilauea volcano on Hawaiʻi Island has been active for several years, and the levels of SO_2 emissions are being monitored by the United States Geological Survey. In addition to volcanoes being large sources of SO_2, they also emit significant amounts of NO_X. Volcanic activity on Hawaiʻi Island is by far the largest source of both SO_2 and NO_X in the state and dominates visibility impairment to Class I areas as to completely obscure any small impact from anthropogenic sources. Significant portions of direct Particulate Matter (PM) emissions are due to volcanic activity. Whatever minimal impact of the SO_2, NO_X, and PM emissions from power plants are projected to be eliminated when the plant units wind down well before the end point of the Regional Haze Rule in 2064 pursuant to Hawaiʻi's State Law: Renewable Portfolio Standards (RPS). Thus, the DOH should not consider SO_2, NO_X, or PM controls for the Second Decadal Period Review for Maalaea.

2.2.4. Renewable Portfolio Standards

For the reasons stated above and based on AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, SO_2, NO_X, and particulate matter, 10 microns or less in diameter (PM_{10}) emissions from Maalaea do not significantly contribute to regional haze at the Class I areas. The low impact that Maalaea may have on haze is already being reduced through conversion of electric generation to renewable energy sources as mandated by the RPS (Hawai'i Revised Statute (HRS) §269-92) and consistent with the Hawai'i Clean Energy Initiative (HCEI). Both past and projected future decreases in fossil-fueled electric generating unit (EGU) usage are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the RHR. The RPS will substantially reduce emissions of haze precursors (especially SO_2) by 2045. Therefore, further requirements for controls would not affect the showing of further progress under the RHR and, thus, are not needed at this time. This is further discussed in Appendix C to this report. Although RPS is listed as a control measure (which is consistent with the Hawai'i Progress Report for Phase 1), it was not necessary to review the RPS in the context of the four-factor analysis as these measures are already planned for implementation and although there are additional costs, they are inherent in the RPS program.

3. SULFUR DIOXIDE FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that SO_2 emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 3-1 lists the baseline SO_2 emissions for Maalaea.

Table 3-1. Baseline SO_2 Emissions

Unit	Fuel Sulfur [A]	SO_2 Emissions (lb/MMBtu) [B]	SO_2 Emissions (TPY) [C]
M1	0.0005%	4.71E-04	1.47E-03
M2	0.0005%	4.71E-04	8.54E-04
M3	0.0005%	4.71E-04	1.46E-03
M4	0.0567%	0.0576	1.5
M5	0.0567%	0.1039	2.0
M6	0.0567%	0.0576	1.1
M7	0.0567%	0.0975	2.1
M8	0.0567%	0.0576	1.1
M9	0.0567%	0.0576	1.8
M10	0.0567%	0.0576	11.6
M11	0.0567%	0.0576	10.1
M12	0.0567%	0.0576	11.4
M13	0.0567%	0.0576	11.0
X1	0.0005%	0.0005	1.53E-03
X2	0.0005%	0.0005	1.54E-03
M14	0.0567%	0.0576	31.7
M16	0.0567%	0.0576	37.1
M17	0.0567%	0.1017	58.8
M19	0.0567%	0.1031	53.8
		Total	**235.2**

[A] Calendar year 2017 annual average fuel sulfur contents.

[B] The SO_2 emission factors for units M1-M4, M6, M8-M16 and X1 and X2 are based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average fuel density (7.04 lb/gal for ULSD; 6.97 lb/gal for diesel) and higher heating value (137,933 Btu/gal for ULSD; 137,169 Btu/gal for diesel). The SO_2 emission factors for units M5, M7, M17 and M19 are based the monthly reported emissions on the 2017 Annual Emissions Report Forms; Diesel Engine Generators Units M5 and M7 and Combustion Turbine Generators Units M17 and M19.

[C] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Diesel engine generators M1, M2, M3, X1, and X2 currently burn Ultra Low Sulfur Diesel (ULSD); thus, a four-factor analysis for these units is not required for SO_2. A four-factor analysis for the remaining units, M4 through M19 was conducted.

3.1. SULFUR DIOXIDE CONTROL OPTIONS

The characterization of emission controls available and applicable to the source is a necessary step before the four factors can be analyzed. SO_2 emissions are generated during fuel oil combustion from the oxidation of sulfur contained in the fuel. Available SO_2 control technologies are:

- Flue Gas Desulfurization (FGD) systems
    - Dry Sorbent Injection (DSI)
    - Spray Dryer Absorber (SDA)
    - Wet Scrubber
    - Circulating Dry Scrubber (CDS)
- Fuel Switching to a lower distillate fuel
- Renewable Portfolio Standards (RPS)

The feasibility of these controls is discussed in the following sections.

3.1.1. Post-Combustion Controls

FGD applications have not been used historically for SO_2 control from diesel engines generators and combustion turbines generators. There are no known FGD applications for similar diesel engines and combustion turbines and the performance of FGDs on diesel engines generators and combustion turbines generators is unknown. The EPA took this into account when evaluating the Best Available Retrofit Technology (BART) presumptive SO_2 emission rate for oil-fired units and determined that the presumptive emission rate should be based on the sulfur content of the fuel oil, rather than on FGD[9]. Since there are no applications of FGD on diesel engine generators and combustion turbine generators in the U.S., FGD is considered technically infeasible for the control of SO_2 from the Maalaea diesel engine generators and combustion turbine generators.

3.1.2. Fuel Switching

The Maalaea diesel engine generators (M4 through M13) and combustion turbine generators (M14, M16, M17, and M19) currently burn diesel with a maximum sulfur content of 0.4 percent by weight. The average sulfur content of the diesel burned in 2017 was approximately 0.0567 percent by weight. Switching to a lower sulfur fuel would reduce SO_2 emissions in proportion to the reduction in fuel sulfur content.[10] ULSD has a maximum sulfur content of 0.0015 percent by weight and is available and a technically feasible option. The SO_2 four-factor analysis evaluates the Maalaea diesel engine generators and combustion turbine generators switching to ULSD.

3.1.3. Renewable Portfolio Standards

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that SO_2 emissions from Maalaea do not significantly contribute to regional haze. The small impact that Maalaea may have on haze is already being reduced through conversion of electric generation to renewable energy sources as mandated by the RPS (Hawai'i Revised Statute (HRS) §269-92) and consistent with the HCEI. Both past and projected future decreases in fossil-fueled EGU usage are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the RHR. The RPS will substantially reduce emissions of haze precursors (especially SO_2) by 2045. Therefore, further requirements for controls would not affect the showing of further progress

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[9] *Summary of Comments and Responses on the 2004 and 2001 Proposed Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations* EPA Docket Number OAR-2002-0076.

[10] Natural gas has less sulfur than the existing residual fuel oil. However, natural gas is not a technically feasible option because there is no utility-scale natural gas supply in Hawai'i.

under the RHR and, thus, are not needed at this time. This is further discussed in Appendix C to this report. Although RPS is listed as a control measure (which is consistent with the Hawaiʻi Progress Report for Phase 1), it was not necessary to review the RPS in the context of the four-factor analysis as these measures are already planned for implementation and although there are additional costs, they are inherent in the RPS program.

3.2. FOUR-FACTOR ANALYSIS

As discussed above, fuel switching to a ULSD is the only feasible option to reduce SO_2 emissions. For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for switching to a ULSD are discussed in the following sections.

3.2.1. Cost of Compliance

The cost effectiveness of the fuel switching was determined by calculating the annual incremental cost of switching to ULSD divided by the reduction in SO_2 emissions. Maalaea currently obtains diesel from local suppliers; current fuel costs were obtained from 2019 fuel purchases. The fuels are refined on Oahu and changes in quantities of ULSD would require new contracts with fuel suppliers. This adds a level of uncertainty to the cost of compliance.

Table 2-2 presents a summary of the cost effectiveness of switching to ULSD with a maximum sulfur content of 0.0015 percent by weight. The cost effectiveness is determined by dividing the annual cost increase in fuel by the annual reduction in SO_2 emissions. The cost effectiveness of switching to ULSD is $10,357 per ton of SO_2 and will increase the Maalaea fuel cost by 1.85 million dollars ($1,850,000) annually and 85 million dollars ($85,0000,000) over fifteen (15) years.

3.2.2. Time Necessary to Achieve Compliance

If the DOH determines that switching to ULSD is needed to achieve reasonable progress, it is anticipated that this change could be implemented within two to three years.

3.2.3. Energy and Non-Air Quality Environmental Impacts

There are no energy and non-air quality environmental impacts of compliance for fuel switching. The cost increase associated with fuel switching to a lower sulfur fuel will increase the cost of the electricity produced by Maalaea. This increase will impact the price of electricity for Maui Electric customers.

3.2.4. Remaining Useful Life

The cost of compliance does not contain any capital costs. Therefore, the remaining useful lives of the Maalaea diesel engine generators and combustion turbine generators are not needed to annualize the capital cost.

Table 3-2. SO_2 Cost Effectiveness of Switching to ULSD

	Current Diesel (0.4% Maximum Sulfur) [A]					ULSD (0.0015% maximum Sulfur) [B]						
Unit	**2017 Average Sulfur Content**	**Fuel Heating Value (HHV) (Btu/gal)**	**Annual Fuel Usage (gal/yr)**	**2017 Annual Heat Input (MMBtu/yr)**	**2017 SO_2 Emissions [C] (tpy)**	**Fuel Heating Value (HHV) (Btu/gal)**	**Annual Fuel Usage (gal/yr)**	**Controlled SO_2 Emissions (tpy)**	**SO_2 Reduced (tpy)**	**Fuel Cost Differential [D] ($/Gal)**	**Fuel Cost Differential [D] ($/yr)**	**SO_2 Cost Effectiveness ($/ton)**
M4	0.0567%	137,169	368,268	50,515	1.5	137,934	366,225	0.04	1.42	0.04	14,649	10,347
M5	0.0567%	137,169	280,704	38,504	1.1	137,934	279,147	0.03	1.08	0.04	11,166	10,347
M6	0.0567%	137,169	278,524	38,205	1.1	137,934	276,979	0.03	1.07	0.04	11,079	10,347
M7	0.0567%	137,169	313,927	43,061	1.2	137,934	312,185	0.03	1.21	0.04	12,487	10,347
M8	0.0567%	137,169	279,114	38,286	1.1	137,934	277,566	0.03	1.07	0.04	11,103	10,347
M9	0.0567%	137,169	465,609	63,867	1.8	137,934	463,026	0.05	1.79	0.04	18,521	10,347
M10	0.0567%	137,169	2,933,686	402,410	11.6	137,934	2,917,409	0.31	11.28	0.04	116,696	10,347
M11	0.0567%	137,169	2,565,572	351,916	10.1	137,934	2,551,338	0.27	9.86	0.04	102,054	10,347
M12	0.0567%	137,169	2,882,514	395,391	11.4	137,934	2,866,521	0.30	11.08	0.04	114,661	10,347
M13	0.0567%	137,169	2,784,528	381,950	11.0	137,934	2,769,078	0.29	10.71	0.04	110,763	10,347
M14	0.0567%	137,169	8,037,944	1,102,554	31.7	137,934	7,993,347	0.84	30.90	0.04	319,734	10,347
M16	0.0567%	137,169	9,394,316	1,288,606	37.1	137,934	9,342,193	0.99	36.12	0.04	373,688	10,347
M17	0.0567%	137,169	8,435,032	1,157,022	33.3	137,934	8,388,232	0.89	32.43	0.04	335,529	10,347
M19	0.0567%	137,169	7,612,681	1,044,222	30.1	137,934	7,570,443	0.80	29.27	0.04	302,818	10,347

[A] Based on 2017 average fuel properties and fuel usage.

[B] Based on 2017 average HHV and density for ULSD and contract fuel sulfur limit.

[C] The listed annual SO_2 emissions from M5, M7, M17, and M19 are based on based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average diesel fuel density (6.97 lb/gal) and higher heating value (137,169).

[D] Based on actual fuel purchases by Hawaiian Electric.

3.3. SULFUR DIOXIDE CONCLUSION

The cost effectiveness of switching to ULSD with a maximum sulfur content of 0.0015 percent by weight for M4 through M19 is $10,300 per ton of SO_2 and would increase the fuel cost by $1.85 million ($1,850,000) annually and 85 million dollars ($85,0000,000) over fifteen (15) years. These costs are greater than the BART and reasonable progress thresholds established in the first planning period of $5,600 per ton and $5,500 per ton, respectively.[11] Thus, no fuel changes or add-on controls are proposed for Maalaea.

While there are no fuel changes or add-on controls proposed, other long- term emission reduction strategies, such as those included as part of the Hawaiʻi RPS, are viable alternatives that would create greater benefits.

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[11] *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaiʻi*, U.S. EPA Region 9, May 14, 2012.

4. NITROGEN OXIDES FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that NO_X emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 4-1 lists the baseline NO_X emissions for Maalaea.

Table 4-1. Baseline NO_X Emissions

	NO_X Emissions	
Unit	**(lb/MMBtu)** [A]	**(TPY)** [B]
M1	3.200	10.0
M2	3.200	5.8
M3	3.200	10.0
M4	3.200	80.8
M5	4.296	82.7
M6	3.200	61.1
M7	5.708	122.9
M8	3.200	61.3
M9	3.200	102.2
M10	2.884	580.3
M11	2.877	506.2
M12	2.027	405.9
M13	2.171	419.5
X1	1.586	5.2
X2	1.614	5.3
M14	0.155	85.4
M16	0.153	98.6
M17	0.133	76.7
M19	0.127	66.4
	Total	**2,786.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

4.1. NITROGEN OXIDES CONTROL OPTIONS

The characterization of emission controls available and applicable to the source is a necessary step before the four factors can be analyzed. NO_X emissions are produced during fuel combustion when nitrogen contained in the fuel and combustion air is exposed to high temperatures. The origin of the nitrogen (i.e., fuel versus combustion air) has led to the use of the terms "thermal NO_X" and "fuel NO_X". Thermal NO_X emissions are produced when high combustion temperatures oxidize elemental nitrogen in the combustion air. Fuel NO_X emissions are created by the oxidation of nitrogen contained in the fuel.

Thermal NO_X emissions are the primary source of NO_X emissions from the Maalaea diesel engine generators and combustion turbine generators.

4.1.1. Diesel Engine Generators

Available diesel engine generators NO_X control technologies are:

- Fuel Ignition Timing Retard (FITR) and Combustion Improvements
- Selective Non-Catalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

The feasibility of these controls is discussed in the following sections.

4.1.1.1. Fuel Ignition Timing Retard and Combustion Improvements

FITR reduces the NO_X emissions by retarding the fuel injection timing causing more combustion to occur during the expansion stroke. This effectively lowers the peak combustion temperatures and pressures and reduces NO_X formation.

- Units M1, M2, M3, X1, and X2 are Electro-Motive Diesels (EMD) Model No. 20-645, and units X1 and X2 use FITR to reduce NO_X emissions. The addition of FITR on units M1, M2, and M3 is a feasible option to reduce NO_X emissions.
- Units M4 through M7 are Cooper-Bessemer diesel engine generators. The original manufacturer was acquired, and the new service provider has been contacted for a feasibility and cost assessment.
- Units M8 and M9 are Colt Industries diesel engine generators, a division of Fairbanks-Morse at the time of manufacture. Fairbanks-Morse, the current service provider, does not offer FITR for these units, but tuning modifications may be available to reduce NO_X emissions. Additional information on this modification, including a cost assessment, has been requested from Fairbanks-Morse.
- Units M10 through M13 are Mitsubishi diesel engine generators. Units M12 and M13 use FITR to reduce NO_X emissions. The manufacturer has been contacted for a feasibility and cost assessment for Units M10 and M11.

Hawaiian Electric will provide the FITR and combustion improvements assessments for units M4 through M11 when the information becomes available.

4.1.1.2. Selective Non-Catalytic Reduction

SNCR is an add-on technology that reduces NO_X using ammonia or urea injection similar to SCR but operates at a higher temperature (1,600 degrees Fahrenheit (°F) to 2,200 °F). Since SNCR does not require a catalyst, this process is more attractive than SCR from an economic standpoint. The operating temperature window, however, is not compatible with diesel engine generator exhaust temperatures, which do not exceed 1,100°F.[12] Therefore, this technology is not technically feasible for the Maalaea diesel engine generators.

4.1.1.3. Selective Catalytic Reduction

SCR is a process in which NO_X in the exhaust gas (which is composed of both nitric oxide (NO) and NO_2) is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed selective because the ammonia preferentially reacts with NO_X rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions are:

[12] *Alternative Control Techniques Document - NO_X Emissions from Stationary Gas Turbines,* EPA-453/R-93-007, January 1993.

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

The SCR process requires a reactor, catalyst, ammonia storage, and an ammonia injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_X concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The estimated NO_X control range for SCR is ninety percent for the diesel engine generators. This control is a technically feasible option for the Maalaea diesel engine generators.

4.1.2. Combustion Turbine Generators

Potential NO_X control technologies for fuel oil-fired combustion turbine generators are:

- Dry Low NO_X (DLN) combustion design
- SNCR
- SCR

The feasibility of these controls is discussed in the following sections.

4.1.2.1. Dry Low NO_X Combustion Design

DLN is a gas-turbine combustion technology that enables gas-turbine combustors to produce low NO_X emission levels without diluents (such as water or steam) or catalysts. DLN technology utilizes a lean, premixed flame as opposed to a turbulent diffusion flame, therefore, requiring the use of natural gas or other gaseous fuels. Since diesel cannot be easily premixed, it is not suitable as a DLN fuel.[13] Therefore, this technology is not technically feasible for the Maalaea combustion turbine generators.

4.1.2.2. Selective Non-Catalytic Reduction

SNCR is an add-on technology that reduces NO_X using ammonia or urea injection similar to SCR but operates at a higher temperature (1,600°F to 2,200°F). Since SNCR does not require a catalyst, this process is more attractive than SCR from an economic standpoint. The operating temperature window, however, is not compatible with gas turbine exhaust temperatures, which do not exceed 1,100°F. Additionally, the residence time required for the reaction is approximately 100 milliseconds, which is relatively slow for gas turbine operating flow velocities.[14] Therefore, this technology is not technically feasible for the Maalaea combustion turbine generators.

4.1.2.3. Selective Catalytic Reduction

SCR refers to the process in which NO_X in the exhaust gas (which is composed of both NO and NO_2) is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed selective because the ammonia preferentially reacts with NO_X rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions are:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

The SCR process requires a reactor, catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_X concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The four

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[13] *Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, Internal Combustion Engines Technologies & Cost Effectiveness*, Northeast States for Coordinated Air Use Management, December 2000.

[14] *Alternative Control Techniques Document - NO_X Emissions from Stationary Gas Turbines,* EPA-453/R-93-007, January 1993.

factors are addressed in Section 4.2. For this analysis, SCR is assumed to reduce NO_X emissions to fifteen parts per million by volume dry (ppmvd) at fifteen percent oxygen (O_2).

4.2. FOUR-FACTOR ANALYSIS

As discussed above, adding FITR to units M1, M2, and M3 and adding SCR for all units are the best feasible option to reduce NO_X emissions. Hawaiian Electric will follow up with the DOH when FITR and combustion improvements assessments from the manufacturers for units M4 through M11 becomes available.

For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for adding FITR for units M1, M2, and M3 and SCR for all units are discussed in the following sections.

4.2.1. Cost of Compliance

For purposes of this four-factor analysis, the capital costs of adding FITR to units M1, M2 and M3 have been estimated based on vendor data. The cost effectiveness of FITR is based on a fifty percent reduction in NO_X emissions. Table 3-2 presents a summary of the cost effectiveness of adding FITR to units M1, M2 and M3. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions. The cost effectiveness of adding FITR to units M1, M2, and M3 ranges from $4,803 per ton to $8,280 per ton of NO_X and the total cost equals 70 thousand dollars ($70,000) annually and one million dollars ($1,000,000) over fifteen (15) years.

For purposes of this four-factor analysis, the capital costs and annual operating costs of adding SCR to the Maalaea diesel engine generators have been estimated based on a combination of vendor data and generic EPA control costing[15]. Due to space constraints, new stacks equipped with catalyst housing are required. The cost effectiveness of SCR is based on a ninety percent reduction in NO_X emissions for the diesel engine generators. Table 3-3 presents a summary of the cost effectiveness of adding SCR to the Maalaea diesel engine generators. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions. The cost effectiveness of adding SCR to the Maalaea diesel engine generators ranges from $6,349 per ton to $37,575 per ton of NO_X and the total cost equals 22 million dollars ($22,000,000) annually and 330 million dollars ($330,000,000) over fifteen (15) years. Appendix A contains the SCR costing details.

For purposes of this four-factor analysis, the capital costs and annual operating costs of adding SCR to the Maalaea combustion turbine generators have been estimated. The SCR costing is based on generic EPA control costing[16] which does not consider Hawaiʻi's remote location which results in additional shipping and higher construction cost. To account for these higher costs, a Maui construction cost multiplier[17] of 1.938 was applied to the SCR cost. The cost effectiveness of SCR is based on reducing NO_X

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[15] *Assessment of Non-EGU NO_X Emission Controls, Cost of Controls, and Time for Compliance, Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS*. Docket ID No. EPA-HQ-OAR-2015-0500, November 2015.

[16] *Ibid*.

[17] The Maui construction cost multiplier is based on cost of construction geographical multipliers from the *RSMeans Mechanical Cost Data 2016* to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.

emissions to fifteen ppmvd at fifteen percent O_2. Table 3-4 presents a summary of the cost effectiveness of adding SCR to the Maalaea combustion turbine generators. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions. The cost effectiveness of adding SCR to the Maalaea combustion turbine generators ranges from $52,101 per ton to $77,367 per ton of NO_X and the total cost equals 7 million dollars ($7,000,000) annually and 105 million dollars ($105,000,000) over fifteen (15) years. Appendix A contains the SCR costing details.

4.2.2. Time Necessary to Achieve Compliance

If the DOH determines that controls are needed to achieve reasonable progress goals, it is anticipated that this change could be implemented in three to five years.

4.2.3. Energy and Non-Air Quality Environmental Impacts

SCR systems require electricity to operate the ancillary equipment. The need for electricity to help power some of the ancillary equipment creates a demand for energy that currently does not exist.

SCR can potentially cause significant environmental impacts related to the storage of ammonia, and the storage of aqueous ammonia above 10,000 pounds is regulated by the EPA's Risk Management Program (RMP) because the accidental release of ammonia has the potential to cause serious injury and death to persons in the vicinity of the release. SCR will likely also cause the release of unreacted ammonia to the atmosphere. This is referred to as ammonia slip. Ammonia slip from SCR systems occurs either from ammonia injection at temperatures too low for effective reaction with NO_X, leading to an excess of unreacted ammonia, or from over-injection of reagent leading to uneven distribution, which also leads to an excess of unreacted ammonia. Ammonia released from SCR systems will react with sulfates and nitrates in the atmosphere to form ammonium sulfate and ammonium nitrate. Together, ammonium sulfate and ammonium nitrate are the predominant sources of regional haze.

4.2.4. Remaining Useful Life

The remaining useful lives of the Maalaea units do not impact the annualized capital costs of potential controls because the useful lives of the Maalaea units is assumed to be longer than the capital cost recovery period, which is fifteen (15) years.

Table 4-2. NO_X Cost Effectiveness of FITR

	Design Nominal Output (MW)	Control Option	2017 NOx Emissions (tpy)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Cost [A] ($)	Capital Recovery Factor [B]	Annualized Capital Cost [C] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	FITR	10.0	50%	5.0	5.0	218,709	0.11	24,013	4,803
M2	2.5	FITR	5.8	50%	2.9	2.9	218,709	0.11	24,013	8,280
M3	2.5	FITR	10.0	50%	5.0	5.0	218,709	0.11	24,013	4,803

[A] The listed capital cost is the total installed cost of an EMD Tier II Pack Update from a 2012 vendor quote. The 2012 cost has been scaled to 2018 dollars using the Chemical Engineering Plant Cost Index (603.1/548.6).

[B] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.11 Where: I = Interest Rate (7% interest)
a = Equipment life (15 yrs)

[C] Capital Cost x CRF

Table 4-3. NO_X Cost Effectiveness of SCR on the Maalaea Diesel Engine Generators

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 NOx Emissions (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Recovery [A] ($)	Annual Operating Cost [B] ($)	Total Annualized Cost [C] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	3,600	SCR	10.0	346.4	90%	1.0	9.0	143,986	46,970	190,956	21,217
M2	2.5	3,600	SCR	5.8	206.8	90%	0.6	5.2	143,986	28,041	172,027	32,955
M3	2.5	3,600	SCR	10.0	340.9	90%	1.0	9.0	143,986	46,224	190,210	21,134
M4	5.6	7,762	SCR	80.8	1,698.0	90%	8.1	72.7	322,529	496,419	818,948	11,262
M5	5.6	7,762	SCR	82.7	1,110.0	90%	8.3	74.4	322,529	324,514	647,043	8,693
M6	5.6	7,762	SCR	61.1	1,252.0	90%	6.1	55.0	322,529	366,029	688,558	12,522
M7	5.6	7,762	SCR	122.9	1,299.0	90%	12.3	110.6	322,529	379,769	702,298	6,349
M8	5.6	7,798	SCR	61.3	1,257.0	90%	6.1	55.2	322,529	369,195	691,724	12,538
M9	5.6	7,798	SCR	102.2	1,929.0	90%	10.2	92.0	322,529	566,569	889,098	9,666
M10	12.5	17,520	SCR	580.3	5,335.8	90%	58.0	522.3	719,931	3,521,039	4,240,970	8,120
M11	12.5	17,520	SCR	506.2	4,677.7	90%	50.6	455.6	719,931	3,086,765	3,806,696	8,356
M12	12.5	17,520	SCR	405.9	5,291.4	90%	40.6	365.3	719,931	3,491,740	4,211,671	11,529
M13	12.5	17,520	SCR	419.5	4,944.2	90%	42.0	377.6	719,931	3,262,626	3,982,557	10,548
X1	2.5	3,600	SCR	5.2	235.0	90%	0.5	4.7	143,986	31,865	175,851	37,575
X2	2.5	3,600	SCR	5.3	228.6	90%	0.5	4.8	143,986	30,997	174,983	36,684

[A] Capital recovery is based on a cost of $57,594 per MW based on an 2012 internal egneering report for units M5 - M9. See Appendix A for the calculation details.

[B] Annual operating cost is based on a cost of $0.0377 per engine horsepower per operating hour based on EPA costing. See Appendix A for the calculation details.

[C] Total Annualized Cost = Capital Recovery + Annual Operating Cost

Table 4-4. NO_X Cost Effectiveness of SCR Maalaea Combustion Turbine Generators

	Control Option	2017 NOx Emissions (tpy)	Controlled Emission Rate [A] (ppmvd @ 15% O_2)	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Annualized Cost ($)	NO_X Cost Effectiveness ($/ton)
M14	SCR	85.4	15	54.9	30.5	1,834,696	60,154
M16	SCR	98.6	15	63.4	35.2	1,834,696	52,101
M17	SCR	76.7	15	49.3	27.4	1,834,696	66,977
M19	SCR	66.4	15	42.7	23.7	1,834,696	77,367

[A] Controlled emissions are based on the ratio of the permit limit of 42 ppmvd @ 15% O_2 to the listed controlled emission rate.

[B] The annual SCR cost is documented in Appendix A.

4.3. NITROGEN OXIDES CONCLUSION

The cost effectiveness of adding FITR on units M1, M2, and M3 ranges from $4,800 per ton to $8,300 per ton of NO_X and the total cost equals 70 thousand dollars ($70,000) annually and one million dollars ($1,000,000) over fifteen (15) years. The cost effectiveness of adding SCR to diesel engine generators M1 through M13, X1, and X2 ranges from $6,300 per ton to $38,000 per ton of NO_X and the total cost equals 22 million dollars ($22,000,000) annually and 330 million dollars ($330,000,000) over fifteen (15) years. The cost effectiveness of adding SCR to combustion turbine generators M14, M16, M17, and M19 ranges from $52,000 per ton to $77,000 per ton of NO_X and the total cost equals 7 million dollars ($7,000,000) annually and 105 million dollars ($105,000,000) over fifteen (15) years. These costs exceed the BART analyses conducted for the first planning period. For the first planning period, the EPA concluded that SCR was not cost effective.[18]

The results of the four-factor analysis for units M1 – M3, X1, X2, and M14 – M19 are consistent with the conclusions, that NO_X controls are not required, reached for the first planning period. Therefore, Hawaiian Electric does not propose any NO_X emissions reduction measures in addition to its RPS program to meet the RHR requirements.

Hawaiian Electric will follow up with the DOH when assessments for FITR and combustion improvements from the manufacturers for units M4 through M11 becomes available.

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[18] *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawai'i*, U.S. EPA Region 9, May 14, 2012.

5. PARTICULATE MATTER FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that PM_{10} emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 5-1 lists the baseline PM_{10} emissions for Maalaea.

Table 5-1. Baseline PM_{10} Emissions

Unit	PM_{10} Emissions (lb/MMBtu) [A]	PM_{10} Emissions (TPY) [B]
M1	0.0573	0.2
M2	0.0573	0.1
M3	0.0573	0.2
M4	0.0573	1.4
M5	0.0573	1.1
M6	0.0573	1.1
M7	0.0573	1.2
M8	0.0573	1.1
M9	0.0573	1.8
M10	0.0540	10.9
M11	0.0540	9.5
M12	0.0949	19.0
M13	0.0989	19.1
X1	0.0573	0.2
X2	0.0573	0.2
M14	0.0267	14.7
M16	0.0460	29.6
M17	0.0292	16.9
M19	0.0307	16.0
	Total	**144.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Diesel engine generators M1, M2, M3, X1, and X2 currently burn ULSD; thus, a four-factor analysis is not required for PM_{10}.

5.1. PARTICULATE MATTER CONTROL OPTIONS

The characterization of emission controls available and applicability to the source is a necessary step before the four factors can be analyzed. PM_{10} emissions from diesel engine generators and combustion turbine generators result from incomplete combustion and noncombustible trace constituents in the fuel. PM_{10} emissions are comprised of both "filterable" and "condensable" PM_{10}. Filterable PM_{10} is that portion of the total PM_{10} that exists in the stack in either solid or liquid state and can be measured on a filter. Condensable PM_{10} is that portion of the total PM_{10} that exists as a gas in the stack but condenses in the cooler ambient air to form particulate matter. Condensable PM_{10} is composed of organic and inorganic compounds and is generally considered to be less than 1.0 micrometers in aerodynamic diameter.

Units M4 through M7 are 4.9 MW Cooper-Bessemer LSV-20-T diesel engine generators and diesel particulate filters have been identified[19] as a possible control option for these diesel engine generators. Units M8 and M9 are 4.9 MW Colt Industries C-P PC2V diesel engine generators and cannot handle the additional backpressure[20]. A review of vendor data shows that diesel particulate filters are generally limited to diesel engine generator applications of less than 4 MW[21]. Units M10 through M13 have a nominal rating of 12.5 MW and the application of diesel particulate filters on units of this size has not been identified. Therefore, diesel particulate filters are not feasible options for units M8 through M13.

The EPA's BACT/RACT/LAER clearinghouse does not list any post-combustion PM_{10} controls for diesel-fired combustion turbine generators. PM_{10} emissions from combustion turbine generators are controlled by good combustion practices. Therefore, additional PM_{10} controls are not feasible options for combustion turbine generators M14, M16, M17, and M19.

5.2. FOUR-FACTOR ANALYSIS

As discussed above, adding diesel particulate filters to units M4 through M7 is the best feasible options to reduce PM_{10} emissions. For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for adding diesel particulate filters to units M4 through M7 are discussed in the following sections.

5.2.1. Cost of Compliance

For purposes of this four-factor analysis, the incremental capital costs of adding diesel particulate filters the SCR systems addressed in Section 4.2 to units M4 through M7 has been estimated. The cost effectiveness of adding diesel particulate filters is based on an eighty-five percent reduction in PM_{10} emissions. Table 5-2 presents a summary of the cost effectiveness of adding diesel particulate filters to units M4 through M7. The cost effectiveness is determined by dividing the annual cost by the annual reduction in PM_{10} emissions. The cost effectiveness of adding diesel particle filters to units M4 through M7 ranges from \$47,592 per ton to \$60,752 per ton of PM_{10}. Appendix A contains the costing details.

5.2.2. Time Necessary to Achieve Compliance

If the DOH determines that controls are needed to achieve reasonable progress goals, it is anticipated that this change could be implemented in three to five years.

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[19] 2012 Internal Engineering Study.

[20] Ibid.

[21] https://www.miratechcorp.com/fa-content/uploads/2014/05/MIR-190904_LTR_Brochure_Update_092319.pdf.

Table 5-2. PM_{10} Cost Effectiveness of Diesel Particulate Filters

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 PM_{10} Emissions (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled PM_{10} Emissions (tpy)	PM_{10} Reduced (tpy)	Incremental Capital Cost [A] ($)	Capital Recovery Factor [B]	Incremental Annualized Capital Cost [C] ($)	PM_{10} Cost Effectiveness ($/ton)
M4	5.6	7,762	DPF	1.4	1,698.0	85%	0.2	1.2	515,823	0.11	56,635	47,592
M5	5.6	7,762	DPF	1.1	1,110.0	85%	0.2	0.9	515,823	0.11	56,635	60,572
M6	5.6	7,762	DPF	1.1	1,252.0	85%	0.2	0.9	515,823	0.11	56,635	60,572
M7	5.6	7,762	DPF	1.2	1,299.0	85%	0.2	1.0	515,823	0.11	56,635	55,524

[A] The listed incremental capital cost is based on the incremental capital cost of adding a DPF to the SCR installation. The SCR and SCR+DPF capital cost are from an 2012 internal engineering report for units M5 - M9. The 2012 cost has been scaled to 2018 dollars using the Chemical Engineering Plant Cost Index (603.1/548.6).

[B] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]   CRF = 0.11   Where: I = Interest Rate (7% interest)

a = Equipment life (15 yrs)

[C] Incremental Capital Cost x CRF

5.2.3. Energy and Non-Air Quality Environmental Impacts

There are no energy and non-air quality environmental impacts of compliance for adding diesel particulate filters.

5.2.4. Remaining Useful Life

The remaining useful lives of the Maalaea units do not impact the annualized capital costs of potential controls because the useful life of each Maalaea unit is assumed to be longer than the capital cost recovery period, which is fifteen (15) years.

5.3. PARTICULATE MATTER CONCLUSION

The cost-effectiveness of adding diesel particulate filters is more than $48,000 per ton of PM_{10} for each diesel engine generator. These costs are similar to the BART analyses conducted for the first planning period. For the first planning period, the EPA concluded that PM_{10} controls were not cost effective.[22]

The results of the four-factor analysis are consistent with the conclusions, that PM_{10} controls are not required, reached for the first planning period. Therefore, Hawaiian Electric does not propose any PM_{10} emissions reduction measures in addition to its RPS program to meet the RHR requirements.

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[22] Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaiʻi, U.S. EPA Region 9, May 14, 2012.

APPENDIX A : DETAILED COSTING

Appendix Table A-1. SCR Capital and Annual Cost Estimates - Diesel Engine Generators

			Table 5-6
Capital Recovery Factor (CRF)			0.11
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2018	603.1	
	2005	468.2	
Capital Cost (2010 dollars)	($/Hp)		$98
Capital Cost (2018 dollars)	($/Hp)		$126
Annualized Capital Cost (2018 dollars)	($/Hp)		$14
Total Annual Cost Including Capital Recovery (2005 dollars)	($/Hp based on 1000 hrs/yr)		$40
Total Annual Cost Including Capital Recovery (2018 dollars)	($/Hp based on 1000 hrs/yr)		$52
Total Annual Cost Minus Capital Recovery (2018 dollars)	($/Hp based on 1000 hrs/yr)		$38
Annual Operating Cost (2018 Dollars)	**($/Hp/Hr)**		**$0.0377**

Source: *Assessment of Non-EGU NO$_X$ Emission Controls, Cost of Controls, and Time for Compliance* , Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

			M5-M9 Estimate
M5 - M9 Nominal Design Output	(MW)		5.9
Capital Recovery Factor (CRF)			0.11
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2018	603.1	
	2012	584.6	
Capital Cost (2012 dollars)	($)		$3,000,000
	($/MW)		$508,475
Capital Cost (2018 dollars)	($/MW)		$524,565.54
Annualized Capital Cost (2018 dollars)	**($/MW)**		**$57,594**

Source: *2012 Internal Engineering Study*

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]

CRF = 0.11

Where:

I = Interest Rate (7% interest)
a = Equipment life (15 yrs)

Appendix Table A-2. SCR Capital and Total Annual Cost Estimate - Combustion Turbine Generators

			M14	M16	M17	M19
MW			20.0	20.0	20.0	20.0
Max Heat Input		(MMBtu/hr)	275	275	275	275
Capital Recovery Factor (CRF)			0.11	0.11	0.11	0.11
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)						
	2018	603.1				
	1990	357.6				
Total Capital Investment (Eq. 1 - 1990 dollars)		($)	$1,672,762	$1,672,762	$1,672,762	$1,672,762
Capital Cost (2018 dollars)		($)	$2,821,149	$2,821,149	$2,821,149	$2,821,149
Annualized Capital Cost (2018 dollars)		($/yr)	$309,747	$309,747	$309,747	$309,747
Total Annual Cost (Eq. 2 - 1990 dollars)		($/yr)	$561,331	$561,331	$561,331	$561,331
Total Annual Cost (2018 dollars)		($/yr)	$946,696	$946,696	$946,696	$946,696
Maui Construction Cost Multiplier [A]			1.938	1.938	1.938	1.938
Total Annual Cost (2018 Dollars)		**($/yr)**	**$1,834,696**	**$1,834,696**	**$1,834,696**	**$1,834,696**

Total capital investment (1990 dollars) = 4744 x (MMBtu/hr) + 368162 Equation 1

Total Annual Cost (1990 dollars) = 1522.5 x (MMBtu/hr) + 142643 Equation 2

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.11

Where:

I = Interest Rate (7% interest)
a = Equipment life (15 yrs)

Source: *Assessment of Non-EGU NO_X Emission Controls, Cost of Controls, and Time for Compliance* , Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

[A] The Maui construction cost multiplier is based on cost of construction geographical multipliers from the *RSMeans Mechanical Cost Data 2016 to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.*

APPENDIX B : HAWAIIAN ELECTRIC REGIONAL HAZE VISIBILITY CONSIDERATIONS

Appendix B:

Hawaiian Electric Regional Haze Visibility Considerations

Fifth Factor Considerations for SO_2, NOx, and PM Controls

AECOM Project Number: 60626547

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March 31, 2020

Hawaiian Electric[1] Regional Haze Visibility Considerations
Fifth Factor Considerations for SO_2, NOx and PM Controls

1. Executive Summary

The EPA has issued multiple guidance documents to assist states and facilities address the requirements of the Regional Haze Rule (“RHR”). This guidance allows states to consider, as part of their review of the Four Factor evaluation of possible emission controls for the Second Decadal Review, a “5th factor” which involves consideration of visibility impacts of candidate control options. This appendix introduces several Hawaiʻi-specific issues that impact the visibility impact of potential sulfur dioxide (“SO_2”), nitrogen oxides (“NOx”) and particulate matter ("PM”) control options for Hawaiian Electric sources relative to the two Class I areas in Hawaiʻi: the Haleakalā National Park on the island of Maui and the Hawaiʻi Volcanoes National Park on Hawaiʻi Island. The issues discussed in this report are summarized below:

1) Due to unique atmospheric chemistry, NOx emissions tend to remain in the gaseous (and invisible) phase in warm weather, and only form NO_3 (“nitrate”) particulate aerosol in cold weather. This is verified by monitoring data in the Interagency Monitoring of Protected Visual Environments (“IMPROVE”) network in the two national parks mentioned above.

2) The persistent East North East (“ENE”) trade winds experienced by the state of Hawaiʻi places emission sources on several islands (or portions of islands such as Maui) downwind of the national parks, limiting the likelihood that any emissions from these sources would even reach the parks. Modeling conducted with the California Puff Model (“CALPUFF”) for the First Decadal Review confirms the minimal potential for haze impact of the subject Hawaiian Electric sources on the islands of Oahu and Maui due to the predominance of the trade winds. The EPA’s Federal Implementation Plan (“FIP”) issued in 2012 agreed with this assessment.

3) EPA previously determined that in Hawaiʻi haze due to direct PM was a very small component of haze and that further controls would not be effective in improving visibility. The observed haze speciation is reviewed in this report to confirm this determination.

4) The State of Hawaiʻi Department of Health Clean Air Branch (“DOH”) should request the EPA (consistent with their first decadal review approach) to set aside NOx and PM from the list of

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[1] “Hawaiian Electric” or the “Company” refers to Hawaiian Electric Company, Inc. (or “HE”), Hawaiʻi Electric Light Company, Inc. (or “HL”) and/or Maui Electric Company, Limited (or “ME”). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

haze precursors for Hawaiʻi due to the unique NOx haze chemistry and climate, leaving SO_2 as the primary precursor pollutant for haze. Hawaiian Electric requests that the DOH make this proposal to the EPA.

5) In the recent past, volcanic activity on Hawaiʻi Island has produced as much as 2 million tons of SO_2 emissions per year[2,3] (emissions vary yearly), as well as roughly 125,000 tons of NOx emissions per year[4]. These volcanic SO_2 emissions are about three orders of magnitude (approximately 1,000 times) greater than anthropogenic SO_2 emissions. Although the IMPROVE monitors indicate that sulfate haze is the most important haze species, it is evident from monthly haze trends and the likelihood of winds from the volcanic activity reaching the IMPROVE monitors that the overwhelming sulfate haze influence comes from natural sources (i.e., volcanic activity).

The locations of the affected Hawaiian Electric sources and the two national parks are shown in Figure B-1. The remainder of this appendix presents details of the above issues and recommendations for how this information should be considered in selection of facilities for Four-Factor analyses and for evaluating potential pollutant control options.

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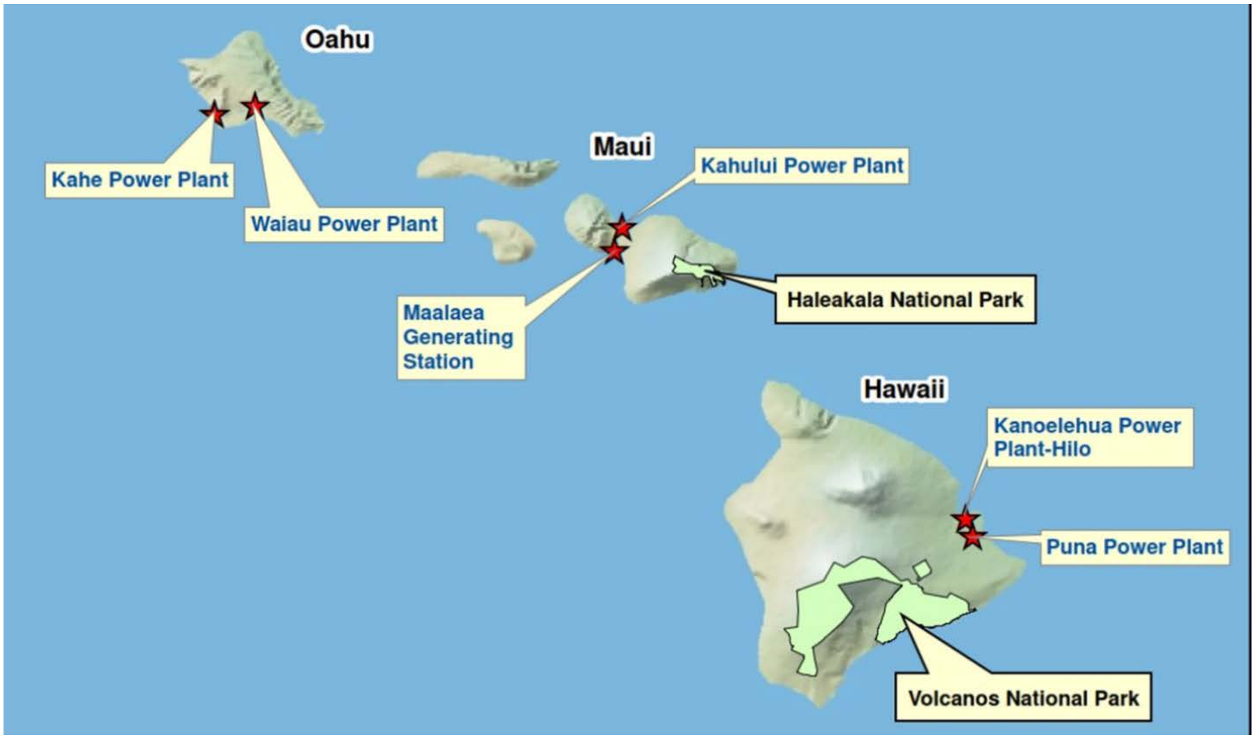
[2] Information on the volcanic SO_2 emissions in 2014 was provided by the EPA in their SO_2 National Ambient Air Quality Technical Support Document at EPA's 2016 SO_2 NAAQS TSD, at https://www.epa.gov/sites/production/files/2016-03/documents/hi-epa-tsd-r2.pdf.

[3] Information on 2014-2017 volcanic SO_2 emissions is available in this journal article: Elias T, Kern C, Horton KA, Sutton AJ and Garbeil H. (2018) Measuring SO_2 Emission Rates at Kīlauea Volcano, Hawaii, Using an Array of Upward-Looking UV Spectrometers, 2014–2017. *Front. Earth Sci.* 6:214. doi: 10.3389/feart.2018.00214. https://www.frontiersin.org/articles/10.3389/feart.2018.00214/full.

[4] The 125,000 tons per year of NOx assumes NOx emissions rate equals 6% of SO_2 emissions rate. The 6% is derived from worldwide volcanic NOx emissions estimate of 1.0 Teragram ("Tg" – trillion grams)/year ("yr") nitric oxide ("NO") (or 1.5 Tg/yr NO2) from https://www.chemistryworld.com/features/a-volcanic-breath-of-life/3004482.article and worldwide volcanic SO2 estimate of 23 Tg/yr from https://www.nature.com/articles/srep44095.

Figure B-1:
Location of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas



2. EPA Guidance Regarding Considerations of Visibility Impacts

The EPA issued “Guidance on Regional Haze State Implementation Plans for the Second Implementation Period”[5] in August 2019. This guidance allows states to consider, as part of its consideration of emission controls to include for the Second Decadal Review a “5th factor” which involves consideration of visibility impacts of candidate control options. A companion document[6] issued in September 2019 that involves the EPA’s visibility modeling results for 2028 is entitled, “Availability of Modeling Data and Associated Technical Support Document for the EPA's Updated 2028 Visibility Air Quality Modeling”.

On Page 11 of the August 2019 guidance, the EPA states:

> *“When selecting sources for analysis of control measures, a state may focus on the PM species that dominate visibility impairment at the Class I areas affected by emissions from the state and then select only sources with emissions of those dominant pollutants and their precursors.”* . . .

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[5] Available at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.
[6] Available at https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-Transmittal_Memo.pdf.

> *"Also, it may be reasonable for a state to not consider measures for control of the remaining pollutants from sources that have been selected on the basis of their emissions of the dominant pollutants"*

Further, on Page 36 and 37, the EPA states:

> *"Because the goal of the regional haze program is to improve visibility, it is reasonable for a state to consider whether and by how much an emission control measure would help achieve that goal." . . .*
>
> *". . . EPA interprets the CAA and the Regional Haze Rule to allow a state reasonable discretion to consider the anticipated visibility benefits of an emission control measure along with the other factors when determining whether a measure is necessary to make reasonable progress."*

Consequently, the extremely low likelihood for impact to Class I visibility impairment from control of certain facility pollutants and the plant locations relative to the Class I areas is appropriate for consideration when evaluating the need for further control of these emissions for Regional Haze Reasonable Progress.

3. Nitrate Haze Composition Analysis

Nitrate haze composition analyses for the Haleakalā and Hawaiʻi Volcanoes National Parks are available at the IMPROVE web site at http://vista.cira.colostate.edu/Improve/pm-and-haze-composition/. Figure B-2 provides various charts for the haze species composition at the Haleakalā Crater IMPROVE site, and Figure B-3 provides a time series of stacked bars by species for a recent year at that site. Figures B-4 and B-5 provide similar information for the Hawaiʻi Volcanoes IMPROVE site. Note that these figures show information for the worst 20 percent ("%") impaired days, which is the focus of the RHR for reducing haze. The goal for each decadal review is to track the progress of haze reduction for the worst 20% impaired days; reviewing the composition of haze on these days is a key element in understanding what precursor pollutants to control to achieve the goal.

The data for both National Parks shows that the contribution of nitrates to haze is very low as a percentage of the total, but it is also low as an absolute value for extinction (visibility impairment). The total nitrate haze impairment is approximately 1 inverse megameter ("Mm^{-1}"), equivalent to approximately 0.25 deciview ("dv"), or less. This is the impairment at these monitors due to ALL sources, natural and anthropogenic, and as noted below, the volcanic emissions are much greater than the entire state's anthropogenic NOx emissions for recent years with SO_2 volcanic emissions of roughly 2 million tons per year ("TPY").

The minimal impact of nitrate haze is clearly illustrated in the Hawaiʻi National Park monitoring data and is much smaller than found at many monitors in other Class I areas around the country. This is in large part due to the unique chemistry of nitrate haze, as discussed below.

The chemistry of nitrate haze formation is highly dependent upon ambient temperature, and to a lesser extent upon humidity. As discussed in the CALPUFF model formulation[7] and in CALPUFF courses (see Figure B-8), total nitrate in the atmosphere ($TNO_3 = HNO_3 + NO_3$) is partitioned into gaseous nitric acid ("HNO_3") (invisible, and not haze-producing) and nitrate ("NO_3") haze particles according to the equilibrium relationship between the two species, which is affected by temperature and humidity.

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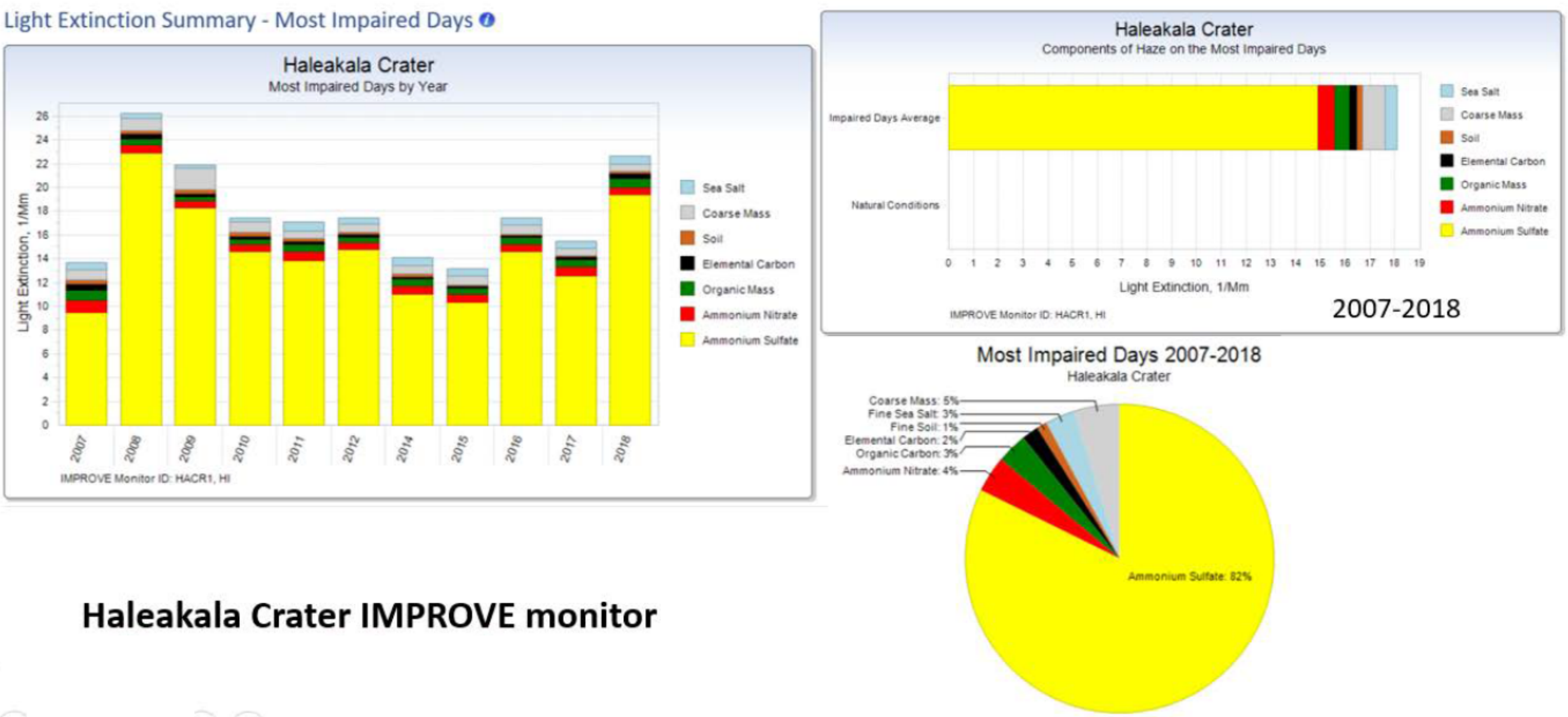
[7] Documentation for the CALPUFF modeling system is available from links provided at https://www.epa.gov/scram/air-quality-dispersion-modeling-alternative-models#calpuff.

Figure B-2: Charts Showing the Worst 20% Haze Days Multiple-Year Species Composition for the Haleakalā Crater IMPROVE Site



Data source for Figures B-2 through B-5: http://views.cira.colostate.edu/fed/SiteBrowser/Default.aspx?appkey=SBCF_VisSum.

Figure B-3: Time Series of 2018 Daily Haze Extinction Composition Plots for the Haleakalā Crater IMPROVE Site

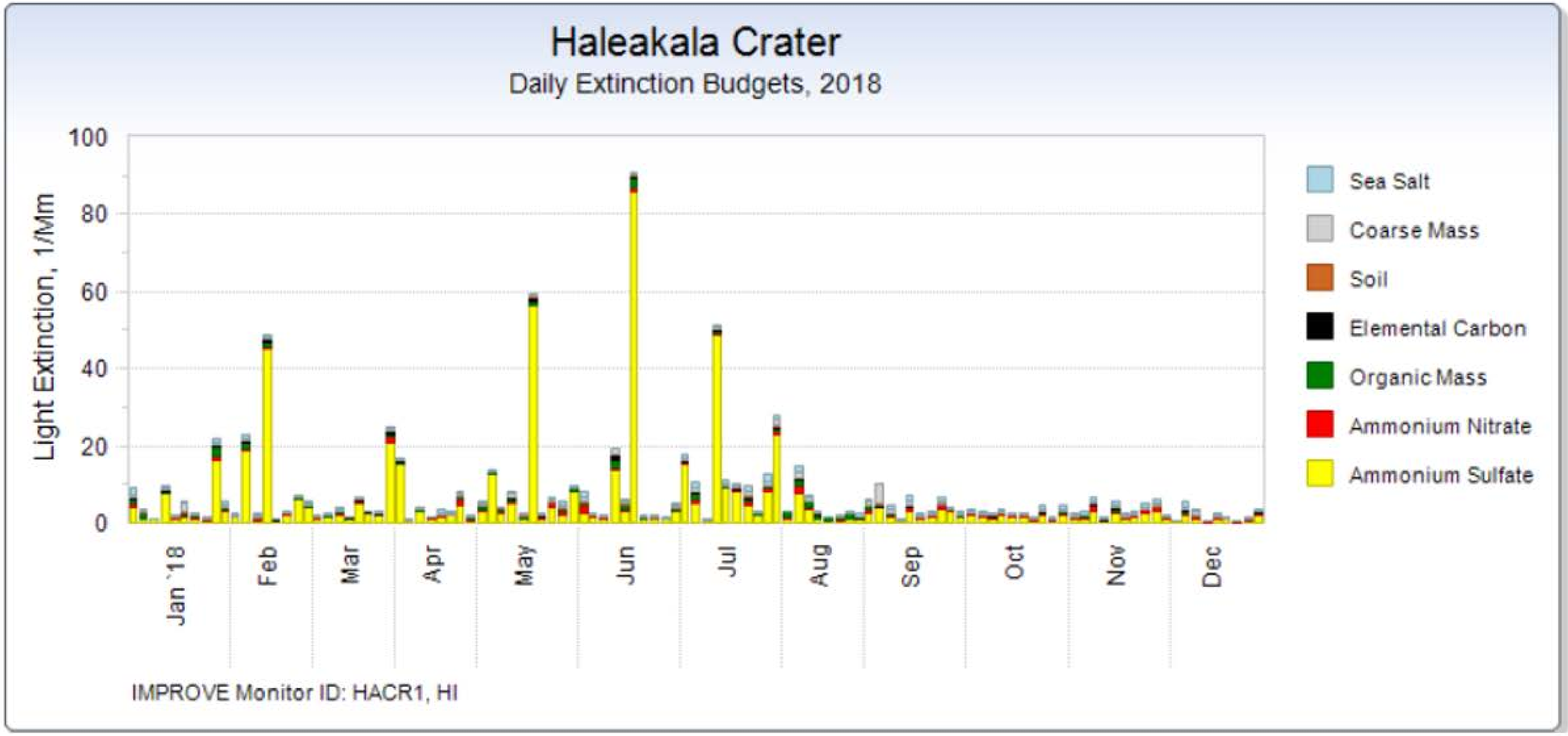
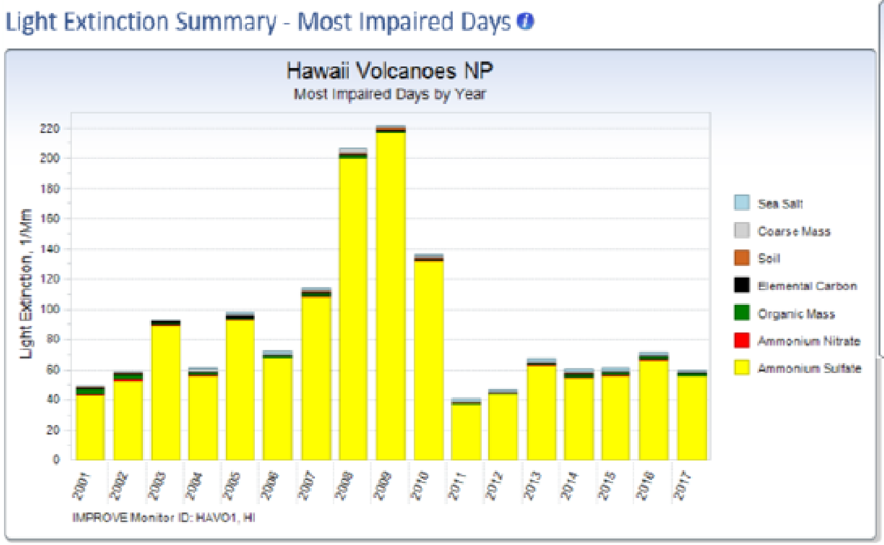
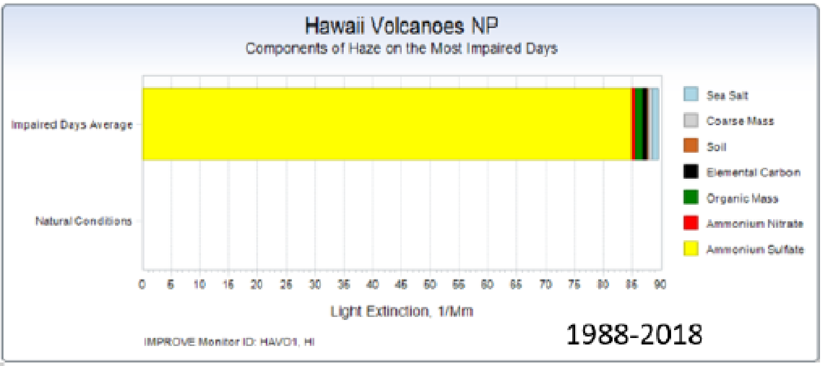
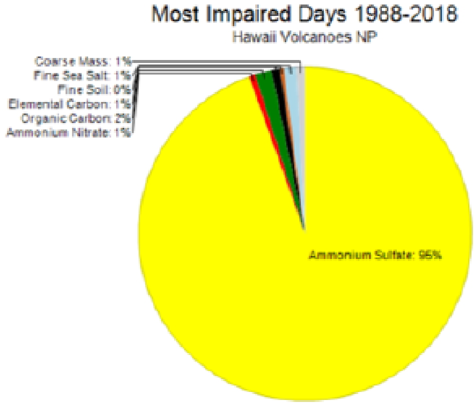


Figure B-4: Charts Showing the Worst 20% Haze Days Multiple-Year Species Composition for the Hawai'i Volcanoes IMPROVE Site

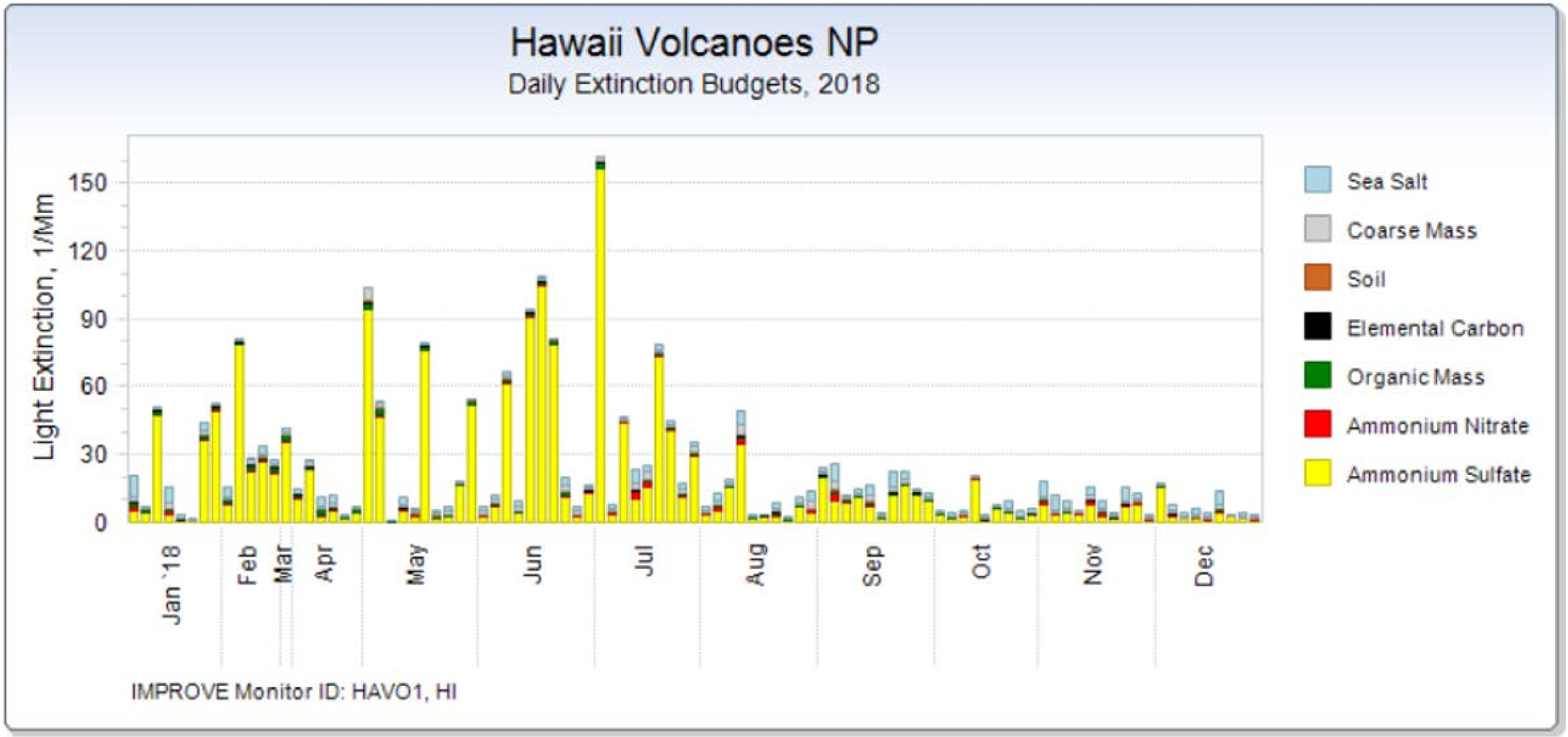




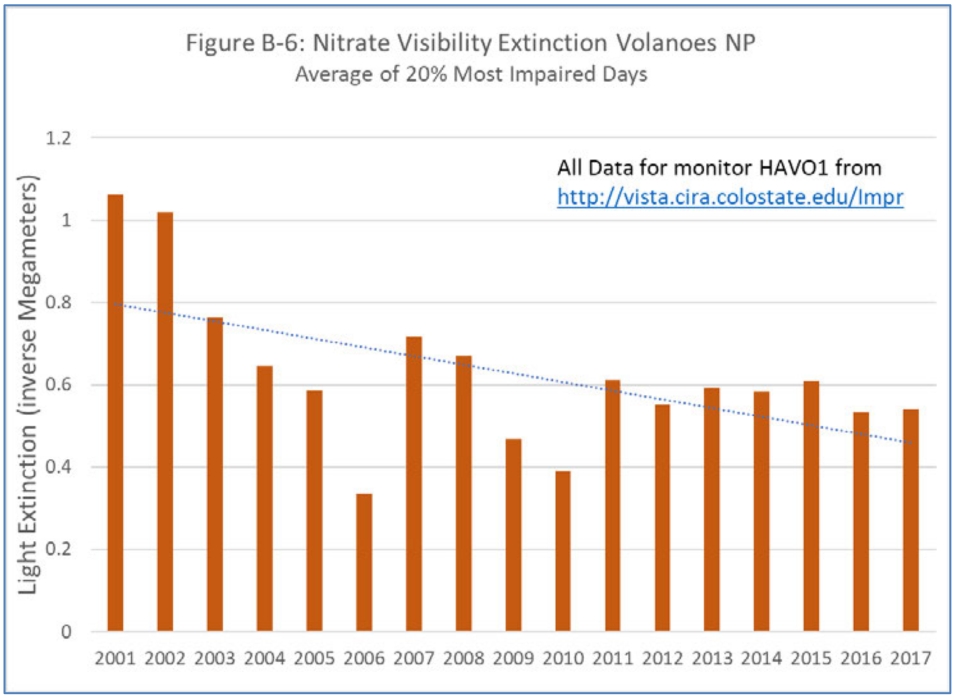


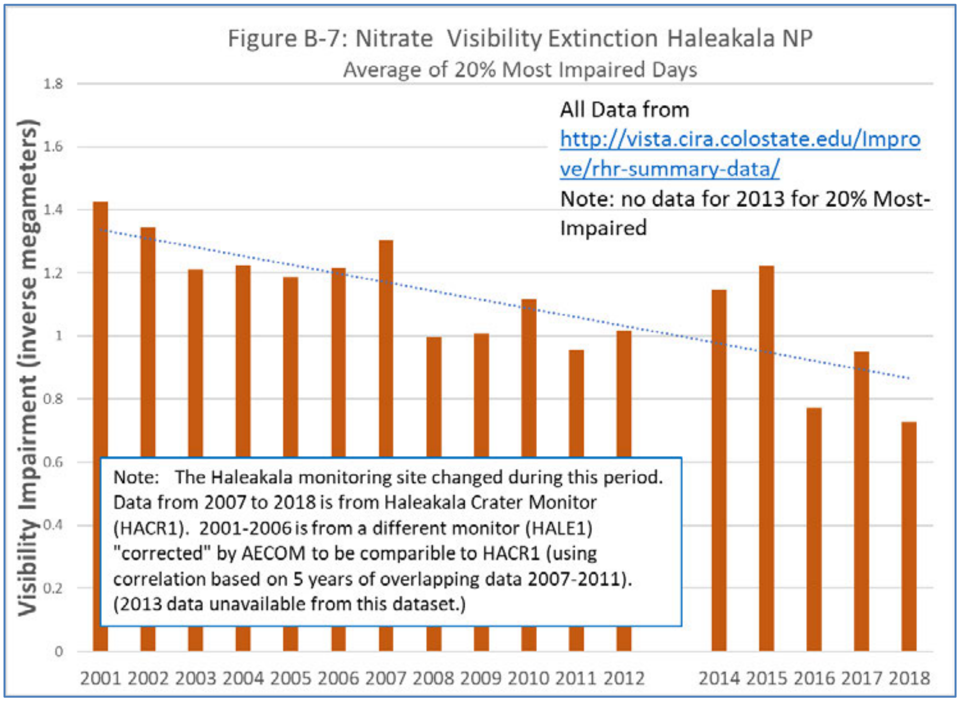
Hawaii Volcanoes NP IMPROVE monitor

Figure B-5: Time Series of 2018 Daily Haze Extinction Composition Plots for the Hawai'i Volcanoes IMPROVE Site



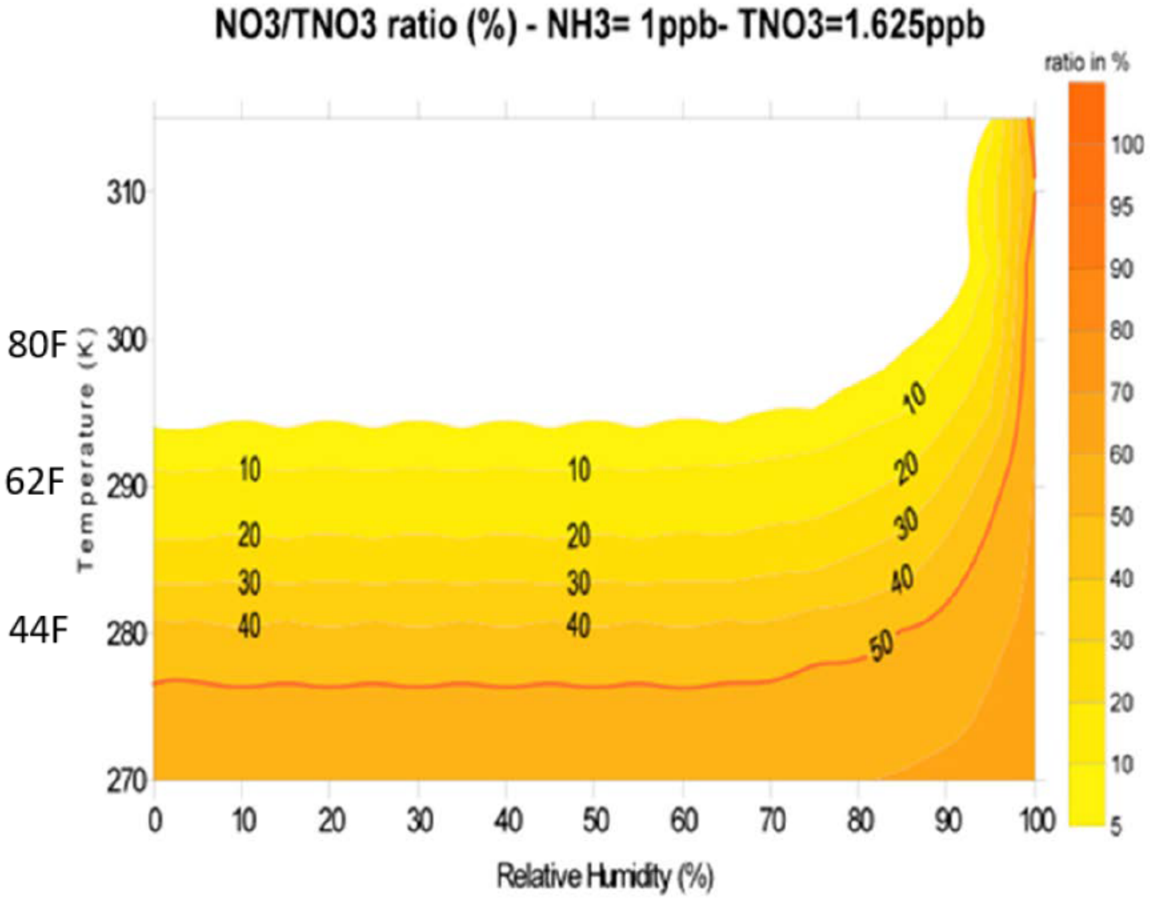
The nitrate contribution to visibility impairment in the above bar charts is shown as a narrow "red" segment. The small size relative to other constituents clearly shows that nitrate is only a small contributor. Additionally, the Figures B-6 and B-7 below which presents only the ammonium nitrate visibility impairment also shows that nitrates, already small contribution, is trending downward.





Note: The Haleakala monitoring site changed during this period. Data from 2007 to 2018 is from Haleakala Crater Monitor (HACR1). 2001-2006 is from a different monitor (HALE1) "corrected" by AECOM to be comparible to HACR1 (using correlation based on 5 years of overlapping data 2007-2011). (2013 data unavailable from this dataset.)

Figure B-8: CALPUFF Example Plot of Aerosol Percentage of Total NOx Equilibrium



The potential for the formation of haze due to NOx emissions is very low in Hawai'i because of the warm weather conditions year-round. This strong dependency of the equilibrium relationship between invisible gaseous HNO_3 and visible NO_3 haze particles as a function of ambient temperature is illustrated in Figure B-8. In Figure B-8, it is evident that for most conditions, the percentage of total nitrate in the form of particulate (NO_3) is less than 20% for temperatures above approximately 286 degrees Kelvin (approximately 55 degrees Fahrenheit). Temperatures at most locations in Hawai'i rarely get that low and are not that low at any of the Hawaiian Electric plant locations.

This dependency of nitrate haze formation as a function of temperature (and season) for more seasonally-varying locations in the United States is shown in the September 2019 EPA modeling report[2] in Figure B-9 (from Appendix A of that report). This figure shows that the thermodynamics of the nitrate haze equilibrium result in much greater particulate formation in winter versus other seasons for more temperate climates, while NOx emissions are expected to be relatively constant over the entire year. This implies that NOx emission reductions would only be effective for haze reduction during cold winter months, while consideration of NOx emission reductions in other months is relatively ineffective.

It should also be noted that volcanic activity on Hawaiʻi Island is the largest source of NOx in the state. Volcanoes are commonly thought of as large sources of SO_2, but they also emit significant amounts of NOx. Laboratory analysis[8] of NOx emissions content in volcanic exhaust indicates a substantial component, likely caused by thermal contact of air with lava. The annual worldwide volcano NOx emissions (as NO_2) is estimated[3] at approximately 1.5 teragrams ("Tg" – trillion grams), while annual worldwide volcano SO_2 emissions are estimated[9] at approximately 23 Tg. This suggests that the level of NOx emissions is approximately equal to 6% of the total SO_2 emissions from volcanos. Hawaiʻi volcanic activity is estimated to have annual SO_2 emissions of approximately 2 million TPY of SO_2. This suggests that the volcanic emissions of NOx in Hawaiʻi are about 125,000 TPY. This level of natural NOx emissions is approximately 3 times greater than all anthropogenic NOx emissions in the entire state of Hawaiʻi (vehicle exhaust, industrial emissions, and other combustion sources) based upon the EPA's state emissions trends data[10] for 2017. Also, these estimated volcanic NOx emissions are approximately 10 times greater than the cumulative total 2017 NOx emissions emitted by all six Hawaiian Electric plants being reviewed for the Second Decadal Review.

In summary, nitrate haze is a very small component in Hawaiʻi's Class I areas, which is expected given nitrate chemistry and is verified by the IMPROVE monitoring data. Additionally, the biggest NOx source is the Kilauea volcano (approximately 125,000 TPY versus statewide[3] approximately 21,000 TPY from transportation and approximately 21,000 TPY from fuel combustion, of which only a small fraction are from Hawaiian Electric facilities). The mulitple-year average of the nitrate haze impact for worst 20% days at the two areas is approximately Mm-1, or less than 0.5 delta-dv. This total nitrate haze impact is less than the de minimis contribution threshold used to eliminate a single source from conderation for controls during the First Decadal Review period.

Due to the low haze impact of NOx (even if every source in the state and the volcano was eliminated), the state of Hawaiʻi should limit the haze precursors control evaluations to SO_2 for the Second Decadal Review. A similar conclusion was reached during the First Decadal Review, for which the EPA did not consider NOx controls to be material. The State of Hawaiʻi Department of Health should work with the EPA to provide this technical justification to remove NOx as a haze precursor for the state of Hawaiʻi.

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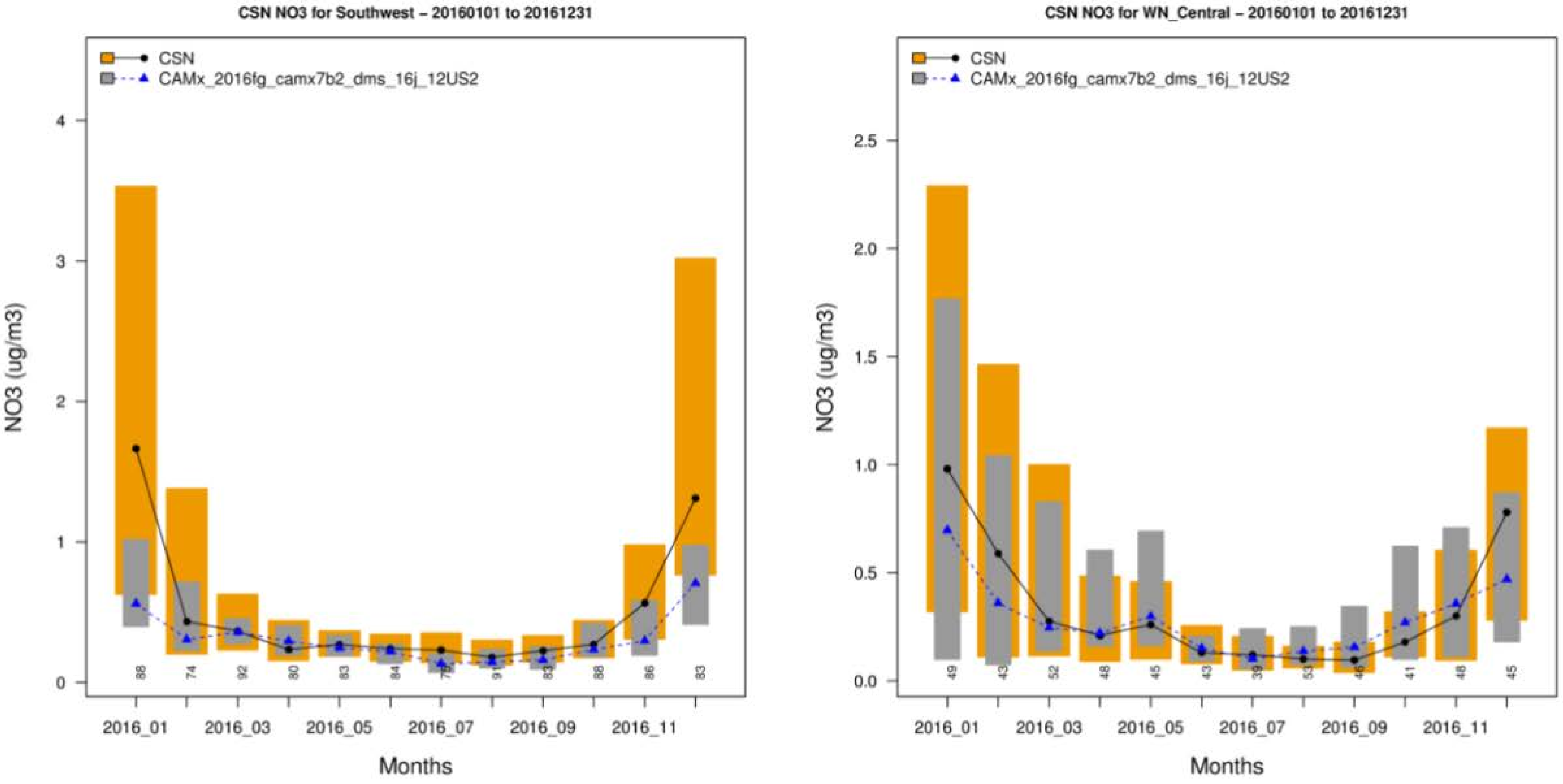
[8] Mather, T., 2004. A Volcanic Breath of Life? Chemistry World, 30 November 2004 Featured Article. https://www.chemistryworld.com/features/a-volcanic-breath-of-life/3004482.article.

[9] Carn, S., V. Fioletov, C. McLinden, C. Li, and N. Krotkov, 2017. A decade of global volcanic SO_2 measured from space. *Sci. Rep*.7, 44095; doi: 10.1038/srep44095. https://www.nature.com/articles/srep44095.pdf.

[10] https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data.

Figure B-9: Monthly Variation of Nitrate Particulate Concentrations for Selected IMPROVE Sites from EPA 2019 Modeling Report



4. PM Species Haze Composition Analysis

In their Federal Implementation Plan Technical Support Document[11], EPA noted that “due to the overwhelming contribution of sulfate to visibility impairment at the nearby Hawaii Volcanoes Class I area, it is unlikely that reductions in these pollutants [NOx and PM]…would have a measurable impact on visibility at that area.”

It is clear from a review of the haze speciation shown in Figures B-2 through B-5 that the contribution to haze of direct particulate species such as elemental carbon, soil, and coarse mass is relatively low. Furthermore, emissions of coarse PM mass (ash) from the volcanic activity can be very high (clearly evident from photos of volcanic activity) to the extent that it may result in aviation alerts. These emissions can be much greater than emissions from power plants and can constitute a significant portion of the direct PM-caused haze shown in Figures B-2 through B-5. The remaining human-caused haze due to direct PM emissions is therefore a very small component of the total haze, and this determination is consistent with EPA’s 2012 assessment.

5. Predominant Trade Winds in Hawaiʻi

The EPA’s FIP for Hawaiʻi for the First Decadal Review (77 FR 61478, October 9, 2012) acknowledged the direction of the predominant trade winds in Hawaiʻi and thus did not require controls on upwind sources (i.e., sources on Oahu and Maui). Figure B-10 shows the locations of the Hawaiian Electric sources and the national parks, along with wind rose plots for airports on Maui and Oahu. The wind rose plots show that the wind is almost always from the northeast and rarely blows from the Hawaiian Electric facilities on Oahu or Maui toward either of Hawaiʻi’s Class I areas.

The EPA CALPUFF modeling conducted for the First Decadal Review confirms the expected low impacts from sources on Maui, even though the sources were relatively close to Haleakalā National Park. This result is due to the fact, as stated above, that winds rarely blow the emissions from sources downwind from the parks back to the parks, and the CALPUFF modeling confirmed the low impact from occasional periods when the wind may blow toward the parks from the sources modeled. The Western Regional Air Partnership (“WRAP”) Q/d analysis that included several sources on the islands of Oahu and Maui in the four-factor analysis did not consider the wind patterns. A review of past modeling and the EPA’s 2012 FIP should lead to a dismissal of those sources from inclusion in four-factor analyses for the second decadal review period.

The geometry and wind roses shown Figure B-10 and previous CALPUFF modeling both indicate that Hawaiian Electric generating stations on Oahu and Maui would have minimal impact to Class I area haze. Because of this, and the minimal impact of NOx due to nitrate chemistry, consideration of potential

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[11] EPA, May 14, 2012. Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii. EPA docket EPA-R09-OAR-2012-0345-0002 via www.regulations.gov.

additional pollution controls at Hawaiian Electric facilities for Regional Haze progress should be limited to SO_2 for sources on Hawaiʻi Island.

6. Natural Sources of SO_2 From Volcanic Activity

Volcanic activity on the Hawaiʻi Island represents a unique and challenging complication to understating haze in Hawaiʻi Class I areas. The Kilauea volcano on Hawaiʻi Island has been active for several years, and the levels of SO_2 emissions are being monitored by the United States Geological Survey. As shown in Figure B-11[12] (related to the SO_2 National Ambient Air Quality Standards implementation and monitoring), there were over 2 million tons of SO_2 emissions from volcanic activity on Hawaiʻi Island in the year 2014, compared to roughly 2,000 tons of power plant SO_2 emissions for that year. As noted in a *Frontiers in Earth Science* 2018 article[13], the volcanic SO_2 emissions have been relatively steady at levels close to 2 million TPY for the period of 2014 to 2017.

The extremely high levels of natural SO_2 emissions present a significant challenge for defining "impaired" haze days because the same pollutant (i.e., SO_2) is emitted by volcanic activity and the power plants and other combustion sources. Therefore, the RHR glidepath for the two Class I areas in Hawaiʻi is difficult to establish if naturally-caused haze is to be excluded from the analysis.

There appears to be very little anthropogenic haze impairment remaining at Haleakalā National Park because there are very few sources on Maui upwind of the park and there are no land masses upwind of Maui for thousands of kilometers. For Hawaiʻi Island, the natural sources of SO_2 are part of (or adjacent to) the park, so they are likely to be a large and continuous source of naturally-caused haze.

Even the anthropogenic sources (from power plants) are projected to be phased out well before the end point of the RHR (i.e., 2064) by Hawaiʻi's State Renewable Portfolio Standards Law ("RPS") implementing requirements to convert 100% of the state's electrical generation to renewable energy sources. This RPS law (Hawaiʻi Revised Statute §269-92) will substantially reduce emissions of haze precursors by 2045. Further details of the past and future benefits of the RPS requirements are detailed in separate Appendix C.

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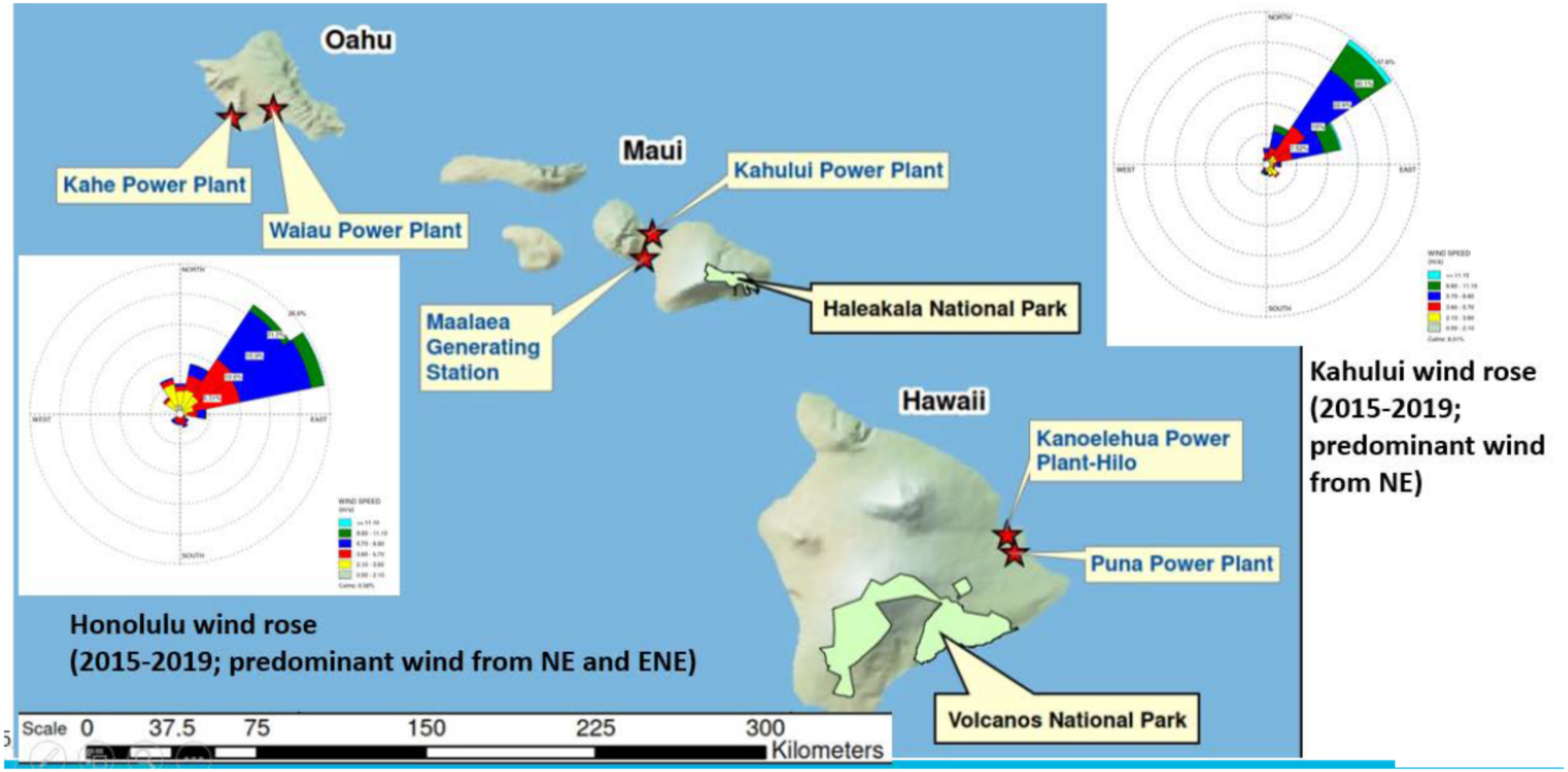
[12] https://www.epa.gov/sites/production/files/2016-03/documents/hi-epa-tsd-r2.pdf.

[13] Elias, T., C. Kern, K. Horton, A. Sutton, and H. Garbeil, 2018. Measuring SO_2 Emission Rates at Kīlauea Volcano, Hawaiʻi, Using an Array of Upward-Looking UV Spectrometers, 2014–2017. *Front. Earth Sci*. 6:214. doi: 10.3389/feart.2018.00214. https://www.frontiersin.org/articles/10.3389/feart.2018.00214/full.

Figure B-10: Geography of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas, with Wind Roses



Kahului wind rose (2015-2019; predominant wind from NE)

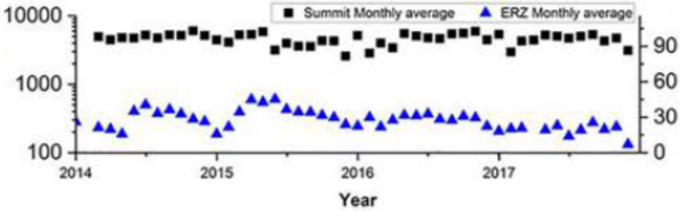
Honolulu wind rose (2015-2019; predominant wind from NE and ENE)

Figure B-11: Geography of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas, with Wind Roses

2017 SO_2 Emissions (from NEI)

site name	TPY SO2
HELCO - Keahole Power Plant	81.94
HELCO - Waimea Power Plant	0.00
HELCO - Kanoelehua Power Plant/ HILL	2167.18
HELCO - Puna Power Plant	186.84

2014-2017 Volcano SO_2 Emissions average about 1.86 Million TPY



ERZ = Eastern Rift Zone

7. Conclusions

The state of Hawaiʻi is isolated from all other states and has very unique regional haze issues due, in part, to its tropical climate, the prevalent trade winds, very large natural emissions of haze precursors, and statewide commitment to renewable energy.

- Emission sources on Oahu and Maui are downwind of Hawaiʻi's Class I areas and do not contribute to haze issues, such that additional emission controls would not contribute to further reasonable progress at either of Hawaiʻi's Class I area National Parks. This is consistent with the EPA's First Decadal Review findings.

- Additionally, NOx emissions do not significantly contribute to haze in Hawaiʻi due the nitrate chemistry and Hawaiʻi's warm climate, and additional NOx controls would likewise not contribute to further reasonable progress. Therefore, NOx should not be regulated as a contributing precursor to haze in Hawaiʻi; especially from Oahu and Maui sources that are downwind of the parks. If they are reviewed as precursors, consideration should be given to their insignificant contribution when evaluating possible controls.

- Direct PM emissions constitute a very small portion of the haze associated with the worst 20% haze days in the Hawaiʻi Class I areas. Furthermore, significant portions of the observed haze in the categories of elemental carbon, soil, and coarse mass are due to volcanic emissions. Therefore, further PM controls on power plant sources would not have a significant benefit for visibility at these Class I areas.

- For the above reasons, the only pollutant that should be considered for possible haze controls in the state of Hawaiʻi is SO_2 which is consistent with the findings of the First Decadal Review. Furthermore, the only Hawaiian Electric sources to be considered for a four factor analysis for SO_2 should be those that are predominantly upwind of a Class I area which include only the Puna and Kanoelehua-Hill Generating Stations on Hawaiʻi Island.

- Hawaiʻi's Class I area haze impacts are principally due to natural sources. Volcanic emissions of precursor SO_2 during the 2014-2017 period of analysis were three orders of magnitude greater than the anthropogenic emissions on Hawaiʻi Island. Volcanic NOx emissions were about three times greater than all the state's NOx emissions. Since these natural emissions are the principal cause of haze at the two Class I areas in the state and are difficult to distinguish from the relatively small amount of anthropogenically-caused haze, photochemical grid modeling is not practical or even needed. The definition of "impaired days" for Hawaiʻi Volcanoes National Park as referenced in some of the figures in this report is uncertain due to the overwhelming influence of natural emissions of SO_2.

- For Haleakalā National Park, with the lack of upwind anthropogenic sources, it could be reasonably concluded that natural conditions are already attained, and no further Reasonable Progress modeling (or controls) is needed. For Hawaiʻi Volcanoes National Park, the only United

States anthropogenic potential sources are those upwind of the park on Hawaiʻi Island; all other sources in the state are not contributing to haze at the Class I areas.

- Implementation of Hawaiʻi's RPS (discussed in detail in Appendix C) will provide a dramatic reduction of virtually all power plant haze-causing emissions in the state of Hawaiʻi well before the year 2064. This Hawaiʻi state law established enforceable requirements that a certain the percentage of electricity must be generated from renewable energy sources by the end of identified benchmark years leading to 100% renewable energy by 2045. The interim targets are 30 percent by 2020, 40 percent by 2030, and 70 percent by 2040 which provide an RPS "glide path" for EGUs that mirrors the RHR visibility improvement glide path for the next few decades. No separate new regional haze measures for EGUs are needed to assure reasonable progress for this decadal period.

Plans for renewable energy sources, the likely reduction in utilization of fossil-fueled electric generation in this interim period, the unique climate and wind patterns, and the difficulty of addressing the high volcanic emissions should be considered in the current planning for the Second Decadal Review process for the state of Hawaiʻi.

APPENDIX C : HAWAI‘I’S RENEWABLE PORTFOLIO STANDARDS CONTRIBUTION TO REGIONAL HAZE PROGRESS

Appendix C:
Hawai‘i’s Renewable Portfolio Standards (“RPS”) Contribution to Regional Haze Progress

AECOM Project Number: 60626547

Prepared for:

Hawaiian Electric

PO Box 2750
Honolulu, HI 96840

Prepared by:

AECOM

AECOM Technical Services, Inc.
500 West Jefferson, Suite 1600
Louisville, KY 40202

March 30, 020

Hawaiʻi's Renewable Portfolio Standards ("RPS") Contribution to Regional Haze Progress

1. Executive Summary

Hawaiʻi's ongoing conversion of fossil-fueled electric generation to renewable energy sources as mandated by the Hawaiʻi Revised Statute ("HRS") §269-92 Renewable Portfolio Standards ("RPS") is significantly decreasing emissions from Hawaiʻi's electric generating stations. Past actual and expected future decreases in usage of fossil-fueled electric generating units ("EGUs") are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the Regional Haze Rule ("RHR"). Emissions from the majority of Hawaiʻi's electric generating plants are not a significant contributor to haze at Class I areas (for reasons explained in Appendix B). Further, their very low impact is being mitigated under the RPS state law. This rate of progress from the RPS law can be relied upon for further emissions reductions from EGUs in the coming years and thus separate further requirements for EGU controls under the RHR are not needed at this time. The following sections of this appendix provide a background on the RPS requirements and progress to date, and high confidence of continued progress consistent with the goals of the RHR.

2. Renewable Portfolio Standards

In 2002 the Hawaiʻi RPS legislation set voluntary goals for converting the islands' electrical generation from fossil fuels to renewable energy. In 2005, the RPS was set into law as binding requirements for Hawaiʻi electric utility companies. The law requires that electric utilities in Hawaiʻi achieve 100% of their electric generation from renewable energy sources by 2045 and meet a series of interim limits for the percentages of their electricity sales that must be provided by renewables (e.g., 30% renewable by 2020, and 40% by 2030, etc.). Renewable energy sources such as solar, hydro and wind energy have no direct emissions. Others such as biomass combustion have significantly lower emissions (especially sulfur dioxide ("SO_2")) than fossil fuels. Consequently, the RPS law results in steady progress in emissions reductions from electric utilities creating, in effect, an "RPS glidepath" providing dramatic reduction of electric generating unit emissions by mid-century.

The RPS program, although not directly related to the Regional Haze Rule ,is providing emissions reductions and improvements to air quality consistent with the goals of the RHR.

Table C-1 shows the interim and final RPS for EGUs along with the Regional Haze adjusted glidepath emissions reductions goals[1].

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[1] Regional Haze Adjusted Glidepath assumes consistent reductions in haze precursor emissions impacts from all U.S. anthropogenic sources from the baseline average of 2000-2004 to zero impacts in 2064, i.e. natural background.

Table C-1 Comparison of RPS and Regional Haze Glidepaths

Year	RPS Renewable Requirement % of Electricity Sales	Regional Haze Glidepath % Visibility Improvement
2010	10%	8%
2015	15%	17%
2020	30%	25%
2030	40%	42%
2040	70%	58%
2045	100%	67%
2065		100%

This table illustrates that the emissions reductions from EGUs under the RPS are similar to the visibility goals of the Regional Haze Program in the intermediate years and become much more stringent in later years. The RPS seeks to achieve 100% renewable electrical supply by 2045, which is twenty years earlier than the RHR target of 2065 to achieve natural background visibility in Class I areas.

3. Historical RPS Achievement

Hawaiian Electric[2], and other electric utility providers in Hawaiʻi, have made excellent progress in developing and supporting renewable energy sources. Figure C-1 below shows the percentage of all electrical sales statewide provided by renewable sources since the RPS inception (green columns).[3] It also shows as a line illustrating the RPS interim standards (with proportional progress assumed between RPS milestone years). This figure illustrates that Hawaiʻi EGUs have made significant progress to date and have been ahead of the RPS interim targets.

Hawaiian Electric represents majority of Hawaiʻi's electric generation. Figure C-2 shows the renewable energy source percentages for this same period specifically for Hawaiian Electric. The data follows the same trend as the statewide figures and this figure also shows a breakdown of the type of renewable energy technology used.

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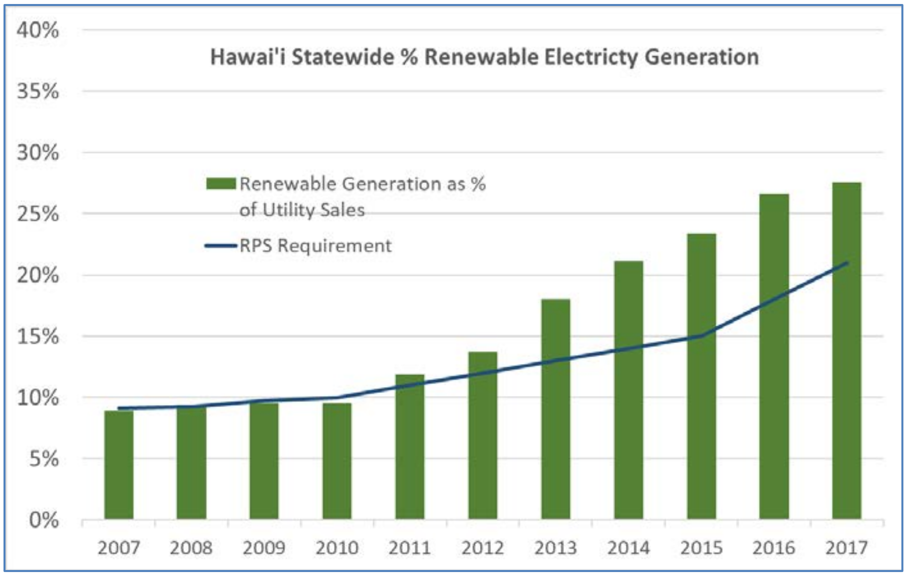
[2] "Hawaiian Electric" or the "Company" refers to Hawaiian Electric Company, Inc. (or "HE"), Hawaiʻi Electric Light Company, Inc. (or "HL") and/or Maui Electric Company, Limited (or "ME"). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

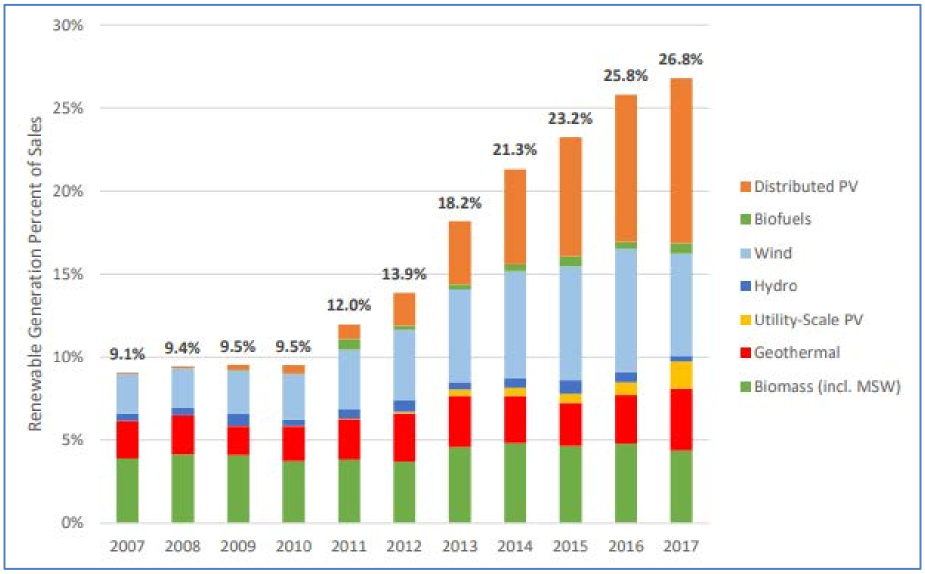
[3] *Hawaiʻi Public Utility Commission* (PUC), *"Report to the 2019 Legislature on Hawaiʻi's Renewable Portfolio Standards", Dec. 2018* https://puc.hawaii.gov/wp-content/uploads/2018/12/RPS-2018-Legislative-Report_FINAL.pdf.

Figure C-1 Statewide Renewable Portfolio Progress



Source: https://puc.Hawaii.gov/wp-content/uploads/2018/12/RPS-2018-Legislative-Report_FINAL.pdf

Figure C-2 Hawaiian Electric Companies RPS Achievement by Generation Technology[4]



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[4] PUC Dec. 2018 Report, Figure 2, page 7.

4. Future RPS Achievability

To date, Hawai‘i’s electric utilities have generally met or exceeded the RPS requirements. Continued progress consistent with RPS is expected to continue. Projects and plans are already in place to continue this rapid RPS shift to renewable energy sources for the period of interest of the next decadal period of the RHR. In its December 2018 report to the state legislature, the Hawai‘i Public Utility Commission (“PUC”) indicated that *“future renewable projects under construction or planned for the HECO Companies and KIUC should ensure that the state remains on track for meeting the 2020 and 2030 RPS targets.”*[5]

Figure C-3 below shows Hawaiian Electric’s projection of percent renewables through 2030 presented in the December 2018 PUC report. This projected progress remains well ahead of the RPS requirements which also is ahead of the requirements of the Regional Haze glidepath goals.

Figure C-3 Hawaiian Electric Companies RPS Expectation by 2030 Technology[6]

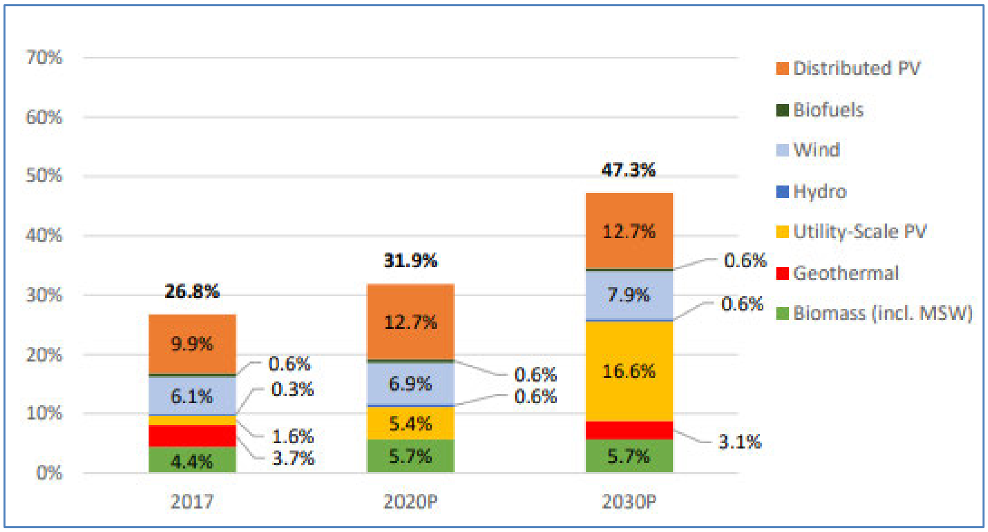

Table C-2 below shows the past actual and future forecast for Hawaiian Electric from the previous two figures (from PUC’s 2018 report) together with the requirements of RPS and the goals of the RHR. Hawaiian Electric’s renewable energy progress and forecast is ahead of both programs. Additionally, Hawaiian Electric has an internal target to achieve 100% renewables by 2040, five years ahead of the RPS requirement and 25 years ahead of the RHR goals.

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[5] PUC Dec. 2018 Report, page 2.

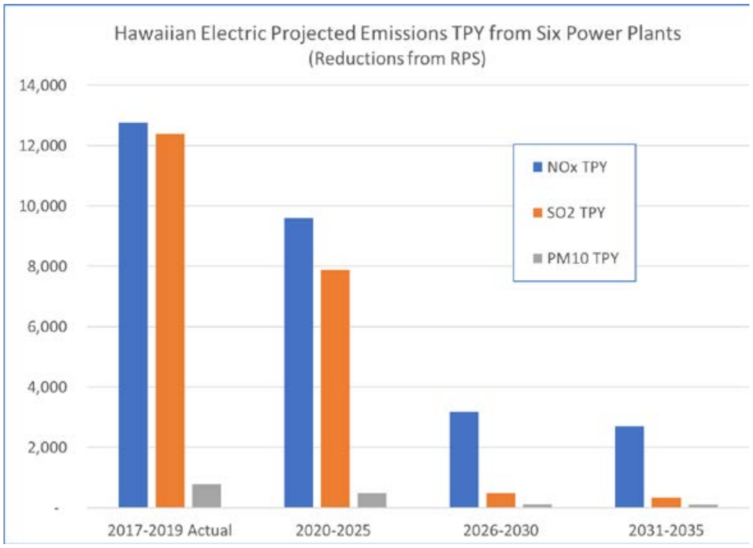
[6] PUC Dec. 2018 Report, Figure 2, page 16.

Table C-2 Comparison of RPS and Regional Haze Glidepaths

Year	RPS Renewable Requirement % of Electricity Sales	Regional Haze Glidepath % Visibility Improvement	Hawaiian Electric % Renewables
2010	10%	8%	9.5% (actual)
2015	15%	17%	23.2% (actual)
2020	30%	25%	31.9% (projection)
2030	40%	42%	47.3% (projection)
2040	70%	58%	100% (goal)
2045	100%	67%	100% (goal)

Hawaiian Electric’s latest projections show an even more rapid shift to renewable energy sources than forecasted in 2018. This will continue to decrease Hawaiian Electric facility emissions. For example, Figure C-4 illustrates Hawaiian Electric’s latest forecast emissions trends for total nitrogen oxides (“NOx”), sulfur dioxide (“SO_2“) and Particulate Matter (“PM_{10}”) emissions (in tons per year “TPY”) from the six power plants (Waiau and Kahe Generating Stations on Oahu, Kahului and Maalaea on Maui, and Kanoelehua-Hill and Puna on Hawaiʻi) requested to conduct Four-Factor Analyses by the Hawaiʻi Department of Health (“DOH”). These dramatic emissions decreases illustrate the expected progress from RPS alone – without any additional RHR measures The forecast emissions shown in Figure C-4 was derived from recent fuel consumption projections based on the resource plans and planning assumptions submitted to the PUC as part of Hawaiian Electric’s 2016 Power Supply Improvement Plan (“PSIP”) which was accepted by the PUC and recent renewable project applications.

Figure C-4 Hawaiian Electric NOx Forecast Emissions



The emissions reduction is quite rapid and most of the projected reduction by Hawaiian Electric are expected to be in place prior to 2028, the next Regional Haze planning milestone.

Although this projection is based on reasonable assumptions, plans are subject to change as there is some uncertainty regarding future projections and forecast assumptions. For this reason and due to energy security issues, Hawaiian Electric cannot commit to specific dates for particular emissions reductions or final retirements of any specific generating station. Nevertheless, Hawaiian Electric is on an aggressive path to end fossil-fueled generation and replace it with renewable energy sources – especially during this next decadal period. This progress should be sufficient for Hawaiian Electric's contribution to the state's efforts regarding reasonable progress of the RHR for the current Regional Haze decadal review.

5. Reliance on RPS for this Regional Haze Decadal Review

The RPS requirements are part of Hawaiʻi state law. An electric utility failing to meet the RPS requirements is subject to enforcement action and penalties by the PUC unless the PUC determines the electric utility is unable to meet the RPS due to factors beyond its reasonable control. However, given the progress to date of the Hawaiʻi electric utilities acquiring renewable generation and expectations for planned renewable projects in the near future, it is reasonable to expect that RPS will result in continued steady progress, at least through 2030.

The DOH can rely on the RPS for regional haze progress without having to impose separate RHR requirements in facility permits. This is supported by EPA guidance which states that "Enforceable requirements are one reasonable basis for projecting a change in operating parameters and thus emissions; energy efficiency, renewable energy, or other such programs where there is a documented commitment to participate and verifiable basis for quantifying any change in future emissions due to operational changes may be another."[7]

Even if progress were slower than currently expected, it would not prevent the RPS from being relied upon as the major EGU contribution to meeting Hawaiʻi's regional haze goals. The time perspective of the Regional Haze Program is long. Making wise decisions that help achieve the long-term goals is important. Hawaiʻi electric utilities are currently focusing resources on advancing renewable energy projects that will permanently displace fossil-fueled unit generation and fossil-fueled combustion emissions. These ongoing RPS efforts help achieve the long-term goals of the RHR and provide permanent emissions reductions and other societal benefits. In contrast, new investments in conventional emissions controls on aging fossil-fueled units provide only modest short-term benefits impose additional costs on rate payers and will have no lasting value when those units are deactivated or retired.

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[7] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period – August 2019 at page 17. https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

Comments on Four – Factor Analysis

1959

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GOVERNOR OF HAWAII

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In reply, please refer to:
File:

20-323E CAB
File No. 0067

July 10, 2020

Ms. Karen Kimura
Director, Environmental Division
Hawaiian Electric
P.O. Box 2750
Honolulu, Hawaii 96840-0001

Dear Ms. Kimura:

Subject: Four-Factor Analysis for Regional Haze
Covered Source Permit No. 0067-01-C
Maui Electric Company, Ltd. (MECO)
Maalaea Generating Station
Located At: Maalaea Generating Station, Maalaea, Maui

The Department of Health, Clean Air Branch (CAB) acknowledges receipt of the subject four-factor analysis on April 22, 2020 and has determined the analysis to be incomplete. Please refer to the attached comments for completing the four-factor analysis. Pursuant to 40 Code of Federal Regulations (CFR) §51.308 (d)(1) of the Regional Haze Rule (RHR), the four-factor analysis will be used to establish control measures and reasonable progress goals for Hawaii's Regional Haze State Implementation Plan (RH-SIP).

The CAB requests that you address the comments and resubmit the subject four-factor analysis with the appropriate revisions by **August 10, 2020.**

If there are any questions regarding this matter, please contact Mr. Mike Madsen of my staff at [redacted]

Sincerely,

Marianne Rossio

MARIANNE ROSSIO, P.E.
Manager, Clean Air Branch

MM:rkb

Attachments

c: Debra Miller, National Park Service, Air Resources Division
Don Shepherd, National Park Service, Air Resources Division
Melanie Peters, National Park Service, NPS-Air

Attachment I

After our review and feedback from the National Park Service (NPS) and Environmental Protection Agency (EPA), Region 9, we have the following comments on the four-factor analysis for Combustion Turbine Generators M14, M16, M17, and M19 and Diesel Engine Generators M1 through M13, X1, X2, and SG1:

a. Section 3.2.2 of the analysis states that fuel switching could be implemented within two (2) to three (3) years. Other facilities have reported that a fuel switch could be accomplished within as short as one (1) year. The amount of time specified for switching fuels at the Maalaea Generating Station seems excessive. Please explain the reason for the long compliance time and whether there are ways to reduce the time for implementing this control measure.

b. Section 3.2.3 states that fuel switching to a lower sulfur fuel will increase the cost of electricity. Although the topic was discussed in the technical support document for the Regional Haze Federal Implementation Plan, it is not something we can generally take into consideration for the regional haze four-factor analysis in this second planning period.

c. What year are the fuel costs based on for switching from diesel fuel with 0.4% sulfur content to ultra-low sulfur diesel (ULSD).

d. Section 4.2.1 states that the cost effectiveness is based on a fifty percent (50%) reduction in nitrogen oxide (NO_X) emissions for fuel injection timing retard (FITR). Provide information that supports the FITR NO_X control efficiency of fifty percent (50%).

e. Section 4.1.1.1 states that the vender was contacted for a quote on the cost of retrofitting Diesel Engine Generators M10 and M11 with FITR. Can Hawaiian Electric just use the same cost and control efficiency from Diesel Engine Generators M12 and M13 that already have FITR and are the same make and model as Diesel Engine Generators M10 and M11?

f. Please evaluate the feasibility of other control measures listed in AP-42, Section 3.3, Gasoline And Industrial Engines, for reducing emissions from the diesel engine generators such as injection rate control and combustion chamber modifications.

g. Section 4.2.4 states that the remaining useful life of the Maalaea Generating Station units do not impact the annualized cost of controls because the useful lives of the equipment are assumed to be at least as long as the capital cost recovery period, which is fifteen (15) years. No planned shutdown dates were provided in the analysis for any of the Maalaea Generating Station units. Please note that in the situation where an enforceable shutdown date does not exist, the remaining useful life of a control under consideration should be the full period of the useful life of that control as recommended by EPA's Control Cost Manual (CCM). The current (2019) CCM specifies a remaining useful life for selective catalytic reduction (SCR) at power plants of thirty (30) years and twenty (20) years for other sources. In the situation of an enforceable requirement for the source to cease operation before the end of the useful life of the controls under consideration, EPA guidance for the second planning period allows the use of the enforceable shutdown date as the end of the remaining useful life. This measure would need to be included in the RH-SIP and/or be federally enforceable. Please see 40 CFR §51.308(f)(2). If Hawaiian Electric agrees to make a commitment to the shutdown of Maalaea Generating Station units through federally enforceable permit limits, the remaining useful life assumed for the control measure is acceptable. The federally enforceable shutdowns could also be used as control measures for showing reasonable progress if the shutdowns occur in the second regional haze planning period (2018-2028). In the situation where an enforceable shutdown date does not exist, the remaining useful life of a control under consideration should be the full period of the useful life of that control as recommended by EPA's Control Cost Manual (CCM).

h. The current prime interest rate (currently at 3.25%) should be used to estimate the cost of additional emission controls, rather than seven percent (7%) used in the analysis. Please see the following site for the current bank prime rate: https://www.federalreserve.gov/releases/h15/. The prime interest rate has not been seven (7%) or higher in the past twelve (12) years. A three percent (3%) interest rate may also be considered.

i. Your four-factor analysis uses vintage cost estimates for SCR and Chemical Engineering Plant Cost Index (CEPCI) to escalate cost. According to the EPA Office of Air Quality Planning and Standards CCM, this should be avoided. Instead, Hawaiian Electric should obtain a current vendor quote for adding SCR to its units.

j. The cost for SCR is in 2018 dollars. Please provide SCR costs in 2019 dollars.

k. The SCR control efficiency of 64% for the combustion turbine generators is underestimated. Control efficiency with SCR is typically higher than 90%.

l. Provide documentation of the internal engineering study in 2012 identifying that Diesel Engine Generators M8 and M9 cannot handle backpressure of particulate filters.

m. In Table A-2 of Appendix A, a “Maui Construction Cost Multiplier” of 1.938 for SCR is used based on the cost of construction geographical multipliers from the “RSMeans Mechanical Cost Data 2016” to account for factors unique to Maui’s location plus an additional factor to account for additional Hawaiian Electric loadings and overhead. Retrofit factors pertain to the difficulty of installing a piece of hardware, regardless of location. While we recognize that it is appropriate to take into consideration the higher costs of transporting equipment and supplies, as well as higher labor rates, in unique areas like Hawai'i or Alaska, those higher costs must be itemized, justified, and documented.

n. Appendix B of the four-factor analysis indicated that, in the recent past, Hawaii’s volcanic sulfur dioxide (SO_2) emissions are about 1,000 times greater than anthropogenic SO_2 emissions and volcanic activity in Hawaii produced as much as two (2) million tons of SO_2 per year. Please note that volcanic SO_2 emissions have significantly decreased after the Kilauea eruption ended in September 2018. The United States Geological Survey (USGS) stated, that in 2019, the summit is the only source releasing enough SO_2 emissions to be quantified using ultra-violet spectroscopy. Preliminary USGS results for 2019 indicate an average summit daily SO_2 emission rate of about 43 tons and an annual total SO_2 emission rate of about 17,119 tons which is far lower than the two (2) million tons of SO_2 reported to be emitted by the volcano in Appendix B. Note that the total combined SO_2 emissions from point sources screened for four-factor analyses were about 18,058 tons per year in 2017 which is 939 tons higher than preliminary USGS estimates of volcanic SO_2 for 2019. Since Kilauea eruptive activity ended in September 2018, those point sources now play a more significant part in SO_2 visibility impacts.

o. Appendix B of the four-factor analysis also noted that volcanic activity on Hawaii Island is the largest source of NO_x in the state based on a NO_x emission estimate for the Kilauea Volcano of roughly 125,000 tons per year. Data, indicating worldwide volcano NO_x and SO_2 emissions of 1.5 and 23 teragrams, respectively, was used for the estimate. It was stated that the NO_x was likely caused by thermal contact of air with lava. Based on the NO_X/SO_2 ratio using the worldwide numbers, it was then assumed that NO_X emissions from Kilauea Volcano are about six percent (6%) of the volcano’s total SO_2 emissions. It was also assumed that Hawaii volcanic activity emits approximately two (2) million tons per year of SO_2. Please note that the global ratio of NO_x/SO_2 is likely not appropriate to use for estimating NO_x emissions from the Kilauea Volcano. Interagency Monitoring of Protected Visual Environments data shows that annual light extinction from ammonium nitrates for the most impaired days at Haleakala National Park over the current visibility period (2014-2018 when the volcano was erupting) are higher than those at Hawaii Volcanoes National park where the volcano is located. Also, while volcanic SO_2 emissions were reported to be as high as two (2) million tons per year when the Kilauea Volcano was erupting, SO_2 emissions have significantly decreased after the Kilauea eruption ended in September 2018. There currently is no lava in the Kilauea summit crater. Instead, a lake of water has formed in the Kilauea crater after the volcano stopped erupting towards the end of 2018. Please refer to: https://earthobservatory.nasa.gov/images/146687/a-new-lakewater-not-lavaon-kilauea.

p. In the four-factor analysis, Hawaiian Electric states that no reduction measures in addition to Hawaii's RPS are proposed to meet the RHR requirements. While provisions mandated by the RPS are subject to enforcement action by the Hawaii Public Utilities Commission, these are state only enforceable requirements which are not federally enforceable under the federal Clean Air Act. The RHR requires federally enforceable emission limits and/or RH-SIP approved rule provisions in establishing the long-term strategy for regional haze. As an option, Hawaiian Electric may propose caps for the emissions of visibility impairing pollutants (SO_2, NO_X, and PM_{10}) based on anticipated emission reductions from the RPS as a reasonable progress measure that could be incorporated into permits. These emission caps would need to occur in the second planning period (2018-2028) in order to be credited as a control measure for reasonable progress. Additional measures for showing reasonable progress include federally enforceable plant shutdowns as described in comment f above. In essence, Hawaiian Electric could propose: 1) federally enforceable conditions for retiring units during the second implementation planning period (2018-2028) and include those units and retirement dates in the four factor analysis along with a four-factor analysis of the remaining equipment; 2) propose federally enforceable emission control measures such as fuel switching or add-on controls with the associated pollutant reductions, or 3) propose federally enforceable permit limits such as emission caps, for operational flexibility, or hour restrictions with the associated compliance dates or any combination of 1, 2, or 3 above.

Responses to Comments on Four – Factor Analysis

Attachment 1
Responses to the DOH's July 10, 2020 Comments
Regional Haze Four-Factor Analysis, Dated April 22, 2020
Maalaea Generating Station
Maui Electric Company, Ltd.

a. Section 3.2.2 of the analysis states that fuel switching could be implemented within two (2) to three (3) years. Other facilities have reported that a fuel switch could be accomplished within as short as one (1) year. The amount of time specified for switching fuels at the Maalaea Generating Station seems excessive. Please explain the reason for the long compliance time and whether there are ways to reduce the time for implementing this control measure.

    Response - Two to three years is a realistic estimate of the timeframe for fuel switching because of several factors: 1) Hawaiian Electric generally requests that the State of Hawaiʻi Public Utilities Commission (Commission) approve fuel contracts and issue its Decision and Order within one year following the filing of the application to the Commission; 2) Hawaiian Electric needs to go through a formal process to request bids from fuel suppliers; 3) Negotiations with the fuel supplier can take up to four months; 4) The schedule for any required infrastructure modifications are dependent on the extent of the required changes; 5) If fuel switching is required at other Hawaiian Electric facilities, the type of fuel to be switched and used, the effect on the fuel supply and ability of the local refinery to accommodate the change may significantly be impacted; and 6) Imported fuel may be required if there is a lack of local supply.

b. Section 3.2.3 states that fuel switching to a lower sulfur fuel will increase the cost of electricity. Although the topic was discussed in the technical support document for the Regional Haze Federal Implementation Plan, it is not something we can generally take into consideration for the regional haze four-factor analysis in this second planning period.

    Response – Fuel costs are directly reflected in customer electricity rates on all islands Hawaiian Electric provides electricity; this is an important cost to the community that must be considered. Hawaiian Electric encourages the DOH to use the flexibility in the EPA's SIP guidance [1] in the selection of control measures necessary to make reasonable progress and to consider additional factors when developing the long-term strategy to improve visibility at Class I areas. Also, note that given the fragile condition of the state's fuel supply and because of Hawaiian Electric's position as a major customer in the market, a fuel supply change could have sweeping effects on the island's market that may not be apparent from the cost estimates associated with Hawaiian Electric such as the ability of the local refinery to accommodate the change and potential need for imported fuel. Hawaiian Electric would suggest that the DOH needs to take these factors into account in its decision-making process.

c. What year are the fuel costs based on for switching from diesel fuel with 0.4% sulfur content to ultra-low sulfur diesel (ULSD).

    Response – The requested costs will be provided in the updated four-factor analysis report.

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[1] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period, August 2019, EPA-457/B-19-003.

d. Section 4.2.1 states that the cost effectiveness is based on a fifty percent (50%) reduction in nitrogen oxide (NO_X) emissions for fuel injection timing retard (FITR). Provide information that supports the FITR NO_X control efficiency of fifty percent (50%).

> **Response** – The fifty percent (50%) reduction in NO_X emissions is based on the ratio of the NO_X emissions factors listed in Table 4-1 in the four-factor analysis for units M1, M2, and M3 (Electro-Motive Diesels (EMD) Model No. 20-645 without FITR) to the emissions factors for units X1 and X2 (EMD Model No. 20-645 with FITR).

$$\frac{3.2\ lb/MMBtu}{(1.586\ lb/MMBtu + 1.614\ lb/MMBtu)\big/_2} = 50\%$$

e. Section 4.1.1.1 states that the vender was contacted for a quote on the cost of retrofitting Diesel Engine Generators M10 and M11 with FITR. Can Hawaiian Electric just use the same cost and control efficiency from Diesel Engine Generators M12 and M13 that already have FITR and are the same make and model as Diesel Engine Generators M10 and M11?

> **Response** – Units M10 through M13 are Mitsubishi diesel engine generators. Units M12 and M13 use FITR to reduce NO_X emissions. M10 and M11 were manufactured in December 1978 and November 1979, respectively, ten (10) years before M12 and M13 were manufactured. The manufacturer was contacted and indicated that a FITR retrofit option is not available for Units M10 and M11. Thus, FITR is not a feasible option for Units M10 and M11.

f. Please evaluate the feasibility of other control measures listed in AP-42, Section 3.3, Gasoline And Industrial Engines, for reducing emissions from the diesel engine generators such as injection rate control and combustion chamber modifications.

> **Response** – The controls listed in AP-42 Table 3.3-3 are for diesel engines (< 600 hp) used in mobile sources. Although, some of the controls are applicable to larger units, most of these controls are integrated into the engine design and are not applicable to retrofit applications. In addition, there is no data on the level of control provided for these controls because the effectiveness is a function of engine design . For these reasons, Hawaiian Electric is unable to perform the requested analysis.

g. Section 4.2.4 states that the remaining useful life of the Maalaea Generating Station units do not impact the annualized cost of controls because the useful lives of the equipment are assumed to be at least as long as the capital cost recovery period, which is fifteen (15) years. No planned shutdown dates were provided in the analysis for any of the Maalaea Generating Station units. Please note that in the situation where an enforceable shutdown date does not exist, the remaining useful life of a control under consideration should be the full period of the useful life of that control as recommended by EPA's Control Cost Manual (CCM). The current (2019) CCM specifies a remaining useful life for selective catalytic reduction (SCR) at power plants of thirty (30) years and twenty (20) years for other sources. In the situation of an enforceable requirement for the source to cease operation before the end of the useful life of the controls under consideration, EPA guidance for the second planning period allows the use of the enforceable shutdown date as the end of the remaining useful life. This measure would need to be included in the RH-SIP and/or be federally enforceable. Please see 40 CFR §51.308(f)(2). If Hawaiian Electric agrees to make a commitment to the shutdown of Maalaea Generating Station units through federally enforceable permit limits, the remaining useful life assumed for the control measure is acceptable. The federally enforceable shutdowns could also be used as control measures for showing reasonable progress if the shutdowns occur in the second regional haze planning period (2018-2028). In the situation where an enforceable shutdown date does not exist, the remaining useful life of a control under consideration should be the full period of the useful life of that control as recommended by EPA's Control Cost Manual (CCM).

Response – The capital recovery period will be increased to the CCM recommended values of 20-years for combustion turbines and diesel engine generators controls. The capital cost recovery period updates will be included in the updated four-factor analysis report. Hawaiian Electric is still evaluating the retirement of its sources as part of the Regional Haze program, but due to the complexity of retirement factors Hawaiian Electric may provide additional information in the updated four-factor analysis report.

h. The current prime interest rate (currently at 3.25%) should be used to estimate the cost of additional emission controls, rather than seven percent (7%) used in the analysis. Please see the following site for the current bank prime rate: https://www.federalreserve.gov/releases/h15/. The prime interest rate has not been seven (7%) or higher in the past twelve (12) years. A three percent (3%) interest rate may also be considered.

Response - Hawaiian Electric will continue to use an interest rate of 7% because it is more appropriate than the prime interest rate for the four-factor analyses. The cost analyses follow the Office of Management and Budget (OMB) and EPA Air Pollution Cost Control Manual (CCM) guidance by using an interest rate of 7% for evaluating the cost of capital recovery. The EPA cost manual states that:

> "*when performing cost analysis, it is important to ensure that the correct interest rate is being used. Because this Manual is concerned with estimating private costs, the correct interest rate to use is the nominal interest rate, which is the rate firms actually face.*" [2]

For these analyses, which evaluates equipment costs that may take place more than five (5) years into the future, it is important to ensure that the selected interest rate represents a longer-term view of corporate borrowing rates. The CCM cites the bank prime rate as one indicator of the cost of borrowing as an option for use when the specific nominal interest rate is not available. Over the past 20 years, the annual average prime rate has varied from 3.25% to 9.23%, with an overall average of 4.86% over the 20-year period.[3] However, the EPA CCM cautions the use of bank prime rates and states:

> "*Analysts should use the bank prime rate with caution as these base rates used by banks do not reflect entity and project specific characteristics and risks including the length of the project, and credit risks of the borrowers.*" [4]

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[2] Sorrels, J. and Walton, T. "Cost Estimation: Concepts and Methodology," *EPA Air Pollution Control Cost Manual*, Section 1, Chapter 2, p. 15. U.S. EPA Air Economics Group, November 2017. https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf

[3] Board of Governors of the Federal Reserve System Data Download Program, "H.15 Selected Interest Rates," accessed April 16, 2020. https://www.federalreserve.gov/datadownload/Download.aspx?rel=H15&series=8193c94824192497563a23e3787878ec&filetype=spreadsheetml&label=include&layout=seriescolumn&from=01/01/2000&to=12/31/2020

[4] Sorrels, J. and Walton, T. "Cost Estimation: Concepts and Methodology," *EPA Air Pollution Control Cost Manual*, Section 1, Chapter 2, p. 16. U.S. EPA Air Economics Group, November 2017. https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf

For this reason, the prime rate should be considered the low end of the range for estimating capital cost recovery. Actual borrowing costs experienced by firms are typically higher.

For economic evaluations of the impact of federal regulations, the OMB uses an interest rate of 7%. OMB Circular A-4 states:

> "*As a default position, OMB Circular A-94 states that a real discount rate of 7 percent should be used as a base-case for regulatory analysis. The 7 percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital. It approximates the opportunity cost of capital, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector.*" [5]

The above statement is confirmed in the EPA CCM with the following statement:

> "*When assessing the societal effect of regulations, such as for EPA rulemakings that are economically significant according to Executive Order 12866, analysts should use the 3% and 7% real discount rates as specified in the U.S. Office of Management and Budget (OMB) 's Circular A-4. The 3% discount rate represents the social discount rate when consumption is displaced by regulation and the 7% rate represents the social discount rate when capital investment is displaced.*" [6]

i. Your four-factor analysis uses vintage cost estimates for SCR and Chemical Engineering Plant Cost Index (CEPCI) to escalate cost. According to the EPA Office of Air Quality Planning and Standards CCM, this should be avoided. Instead, Hawaiian Electric should obtain a current vendor quote for adding SCR to its units.

    Response – The costing method used was developed as updates to EPA's Control Strategy Tool (CoST) to support national- and regional-scale multipollutant air quality modeling analyses. [7]

    Detailed engineering studies, not just vendor quotes, are needed to refine the SCR costing. The process to obtain a vendor quote could take up to two (2) months. Additionally, an engineering study would be required to develop a design which could take up to two (2) months to complete with a cost of approximately $20,000. Due to cost and time constraints, a detailed engineering study cannot be provided at this time.

j. The cost for SCR is in 2018 dollars. Please provide SCR costs in 2019 dollars.

    Response – The Chemical Engineering Plant Cost Index (CEPCI) for 2019 equals 607.5 which represents a 0.7% increase in cost from 2018. The control costs will be adjusted to 2019 dollars. The requested updates will be provided in the updated four-factor analysis report.

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[5] OMB Circular A-4, https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf - "

[6] Sorrels, J. and Walton, T. "Cost Estimation: Concepts and Methodology," *EPA Air Pollution Control Cost Manual*, Section 1, Chapter 2, pp. 16-17. U.S. EPA Air Economics Group, November 2017. https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf

[7] *Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS*, Docket ID No. EPA-HQ-OAR-2015-0500 - Appendix A, *Update of NOx Control Measure Data in the CoST Control Measure Database for Four Industrial Source Categories: Ammonia Reformers, NonEGU Combustion Turbines, Glass Manufacturing, and Lean Burn Reciprocating Internal Combustion Engines, October 2014.*

k. The SCR control efficiency of 64% for the combustion turbine generators is underestimated. Control efficiency with SCR is typically higher than 90%.

> **Response** – The level of control is based on a post controlled NO_X emissions rate of 15 ppmvd at 15% O_2 which is the current permit limit for other GE LM2500 combustion turbines in Hawaiʻi and represents a proven level of control for these LM2500 combustion turbine generators.

l. Provide documentation of the internal engineering study in 2012 identifying that Diesel Engine Generators M8 and M9 cannot handle backpressure of particulate filters.

> **Response** – The requested information is provided in the Maalaea Generating Station's National Ambient Air Quality Standards (NAAQS) Compliance Strategy's Budgetary Cost Estimate for Units M1 through M9 prepared by Black & Veatch dated September 12, 2012. See Attachment 5 included with this Response to Comments attachment.

m. In Table A-2 of Appendix A, a "Maui Construction Cost Multiplier" of 1.938 for SCR is used based on the cost of construction geographical multipliers from the "RSMeans Mechanical Cost Data 2016" to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead. Retrofit factors pertain to the difficulty of installing a piece of hardware, regardless of location. While we recognize that it is appropriate to take into consideration the higher costs of transporting equipment and supplies, as well as higher labor rates, in unique areas like Hawai'i or Alaska, those higher costs must be itemized, justified, and documented.

> **Response** – The use of a retrofit factor in lieu of itemized costing is a common method contained in the EPA CCM. The EPA CCM lists the following factors that impact retrofit costs:
>
> - The amount of available space;
> - Congestion downstream of the combustion turbines (i.e., buildings, heat recovery steam generator, or stack);
> - The capacity, condition, and design margins of the electrical distribution system;
> - The design margins of the existing structural steel support systems;
> - The design pressure drop of the combustion; and
> - The number, nature, and type of existing items that must be relocated to accommodate the SCR and associated systems.
>
> The items listed above are applicable to the Maalaea combustion turbines (M14, M16, M17, and M19). In addition, Hawaiʻi's higher construction cost impacts the cost to address the required equipment upgrades and space constraints, which require relocating existing equipment. The "RSMeans Mechanical Cost Data 2016" was used as a surrogate to the retrofit factor for the combustion turbines.

n. Appendix B of the four-factor analysis indicated that, in the recent past, Hawaii's volcanic sulfur dioxide (SO_2) emissions are about 1,000 times greater than anthropogenic SO_2 emissions and volcanic activity in Hawaii produced as much as two (2) million tons of SO_2 per year. Please note that volcanic SO_2 emissions have significantly decreased after the Kilauea eruption ended in September 2018. The United States Geological Survey (USGS) stated, that in 2019, the summit is the only source releasing enough SO_2 emissions to be quantified using ultra-violet spectroscopy. Preliminary USGS results for 2019 indicate an average summit daily SO_2 emission rate of about 43 tons and an annual total SO_2 emission rate of about 17,119 tons which is far lower than the two (2) million tons of SO_2 reported to be emitted by the volcano in Appendix B. Note that the total combined SO_2 emissions from point sources screened for four- factor analyses were about 18,058 tons per year in 2017 which is 939 tons higher than preliminary USGS estimates of volcanic SO_2 for 2019. Since Kilauea eruptive activity ended in September 2018, those point sources now play a more significant part in SO_2 visibility impacts.

> **Response** – Hawaiian Electric agrees that the volcanic SO_2 emissions have significantly decreased since September 2018. The four-factor analysis report Appendix B will be updated to acknowledge this change in the volcanic emissions. However, Hawaiian Electric does not believe that this changes the overall conclusion of the analysis which indicated that the Maui Electric power plants are not significant contributors to visibility impairment at Hawaiʻi's Class I areas. Although the percent impact of point sources will increase with less volcanic emissions, the absolute value of the point source impacts is unchanged. Given the neglible impact, the cost of control measures cannot be justified.
>
> Maui Electric sources on Maui are not upwind of either Class I area and do not have any significant impact on the visibility at either area. As mentioned in the four-factor analysis report, EPA CALPUFF modeling conducted for the First Decadal Review confirms the expected low impacts from these sources.
>
> As discussed in Section 2.1 of the four-factor analysis report, Step 1 of the EPA SIP guidance is to identify the 20 percent most anthropogenically impaired days, which requires factoring out volcanic impacts. Hawaiian Electric understands that volcanic activity has decreased since the September 2018. The reduction in volcanic activity should be visible in the 2019 IMPROVE monitoring data. The DOH should review the 2019 IMPROVE monitoring data to assist with defining the level of anthropogenic impaired.
>
> Additionally, Hawaiian Electric, as a key affected company, should be allowed to participate as a major stakeholder in discussing and reviewing the EPA's photochemical modeling and the Western Regional Air Partnership's Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) modeling mentioned during the conference call with Hawaiian Electric and the DOH on July 30, 2020.

o. Appendix B of the four-factor analysis also noted that volcanic activity on Hawaii Island is the largest source of NO_X in the state based on a NO_X emission estimate for the Kilauea Volcano of roughly 125,000 tons per year. Data, indicating worldwide volcano NO_X and SO_2 emissions of 1.5 and 23 teragrams, respectively, was used for the estimate. It was stated that the NO_x was likely caused by thermal contact of air with lava. Based on the NO_X/SO_2 ratio using the worldwide numbers, it was then assumed that NO_X emissions from Kilauea Volcano are about six percent (6%) of the volcano's total SO_2 emissions. It was also assumed that Hawaii volcanic activity emits approximately two (2) million tons per year of SO_2. Please note that the global ratio of NO_X/SO_2 is likely not appropriate to use for estimating NO_X emissions from the Kilauea Volcano. Interagency Monitoring of Protected Visual Environments data shows that annual light extinction from ammonium nitrates for the most impaired days at Haleakala National Park over the current visibility period (2014-2018 when the volcano was erupting) are higher than those at Hawaii Volcanoes National park where the volcano is located. Also, while volcanic SO_2 emissions were reported to be as high as two (2) million tons per year when the Kilauea Volcano was erupting, SO_2 emissions have significantly decreased after the Kilauea eruption ended in September 2018. There currently is no lava in the Kilauea summit crater. Instead, a lake of water has formed in the Kilauea crater after the volcano stopped erupting towards the end of 2018. Please refer to: https://earthobservatory.nasa.gov/images/146687/a-new-lakewater-not-lavaon-kilauea.

Response – Hawaiian Electric recognizes that estimates of NO_X emissions from the volcano are uncertain as are the significance of its impact to nitrate haze. Appendix B of the four-factor analysis report will be updated to recognize this and acknowledge that monitoring data does not suggest a large impact from the volcanos. However, more importantly, as discussed in the four-factor analysis report, monitoring data for both National Parks shows that the total contribution of nitrates from all sources to haze is very low as both a percentage of the total impairment, and is also low as an absolute value for extinction (visibility impairment). The total nitrate haze impairment is approximately 1 inverse megameter ("Mm-1"), an extremely small value which is the total due to ALL sources, natural and anthropogenic. The small impact of NO_X emissions to haze formation is due to the unique chemistry of nitrate haze and Hawai'i's generally warm weather year-round as explained in the four-factor analysis report.

Regarding the noted significant decrease in volcanic SO_2 emissions, see the previous response to item n.

p. In the four-factor analysis, Hawaiian Electric states that no reduction measures in addition to Hawaii's RPS are proposed to meet the RHR requirements. While provisions mandated by the RPS are subject to enforcement action by the Hawaii Public Utilities Commission, these are state only enforceable requirements which are not federally enforceable under the federal Clean Air Act. The RHR requires federally enforceable emission limits and/or RH- SIP approved rule provisions in establishing the long-term strategy for regional haze. As an option, Hawaiian Electric may propose caps for the emissions of visibility impairing pollutants (SO_2, NO_X, and PM_{10}) based on anticipated emission reductions from the RPS as a reasonable progress measure that could be incorporated into permits. These emission caps would need to occur in the second planning period (2018-2028) in order to be credited as a control measure for reasonable progress. Additional measures for showing reasonable progress include federally enforceable plant shutdowns as described in comment f above. In essence, Hawaiian Electric could propose: 1) federally enforceable conditions for retiring units during the second implementation planning period (2018-2028) and include those units and retirement dates in the four factor analysis along with a four-factor analysis of the remaining equipment; 2) propose federally enforceable emission control measures such as fuel switching or add-on controls with the associated pollutant reductions, or 3) propose federally enforceable permit limits such as emission caps, for operational flexibility, or hour restrictions with the associated compliance dates or any combination of 1, 2, or 3 above.

Response – As Hawaiian Electric set forth in the four-factor analysis report (see in particular Appendix C) continues to assert that several of its programs can in fact be used to show that their emissions are being reduced in a manner that shows reasonable progress.

EPA's *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period* (SIP Guidance) allows for the use of renewable energy programs as an alternative to permit limits. Also, the SIP Guidance encourages the use of projected 2028 emissions in selecting emission controls required to show reasonable progress and allows for energy efficiency, renewable energy, or other such programs where there is a documented commitment to participate and a verifiable basis for quantifying any change in future emissions due to operational changes. Hawaiian Electric's progress towards meeting the RPS is documented in annual reports to the Public Utility Commission (PUC) see also Appendix C to the Four Factor Reports. In addition, the status of future renewable projects are listed on the *Renewable Project Status Board* on the Hawaiian Electric website.[8] The addition of renewable energy is an

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[8] Renewable Project Status Board (https://www.hawaiianelectric.com/clean-energy-hawaii/our-clean-energy-portfolio/renewable-project-status-board)

operational change that reduces fossil fuel consumption, which results in reductions in emissions of visibility impairing pollutants.

The EPA's Regional Haze SIP Guidance supports the use of the State's RPS as an alternative to permit limits as it states:

" ***Step 3: Selection of sources for analysis***

...

Selection of emissions information when estimating visibility impacts (or surrogates) for source selection purposes

****

All of the techniques described above require estimates of source emissions. Generally, we recommend that states use estimates of 2028 emissions (resolved by day and hour, as appropriate) to estimate visibility impacts (or related surrogates) when selecting sources, rather than values of recent year emissions. By doing so, sources that are projected on a reasonable basis to cease or greatly reduce their operations or to install much more effective emissions controls by 2028 may be removed from further consideration early in the SIP development process, which can reduce analytical costs. Generally, the estimate of a source's 2028 emissions is based at least in part on information on the source's operation and emissions in a representative historical period. However, there may be circumstances under which it is reasonable to project that 2028 operations will differ significantly from historical emissions. Enforceable requirements are one reasonable basis for projecting a change in operating parameters and thus emissions; energy efficiency, renewable energy, or other such programs where there is a documented commitment to participate and a verifiable basis for quantifying any change in future emissions due to operational changes may be another. A state considering using assumptions about future operating parameters that are significantly different than historical operating parameters should consult with its EPA Regional office.

If a state uses a value for emissions in an earlier year, we recommend the state consider whether emissions have appreciably changed (or will change) between the earlier year, the current period, and the projected future year (2028). It is especially important to consider whether source emissions have increased or are likely to increase in the future compared to earlier emissions values.

Use of actual emissions versus allowable emissions

Generally, we recommend that a reasonably projected actual level of source operation in 2028 be used to estimate 2028 actual emissions for purposes of selecting sources for control measure analysis. Source operation during a historical period can inform this projection, but temporary factors that suppressed or bolstered the level of operation in the historical period should be considered, along with factors that indicate a likely increase or decrease in operation.

...

Step 4: Characterization of factors for emission control measures

...

Examples of types of emission control measures states may consider States have the flexibility to reasonably determine which control measures to evaluate, and the following is a list of example types of control measures that states may consider:

...

Energy efficiency and renewable energy measures that could be applied elsewhere in a state to reduce emissions from EGUs.

...

> *EPA understands that some states may be interested in exploring such measures for their second implementation period SIPs, which is generally appropriate. We suggest such states discuss the measures and programs and their incorporation into the SIP with their EPA Regional office..."* [9]

> Based on the above EPA guidance, the selection of controls for the long-term strategy (LTS) can include alternatives to permit limits and rely on projected emissions based on the planned transition to 100% renewable energy. For example various RPS goals across the 48 contiguous states were used as inputs in the EPA's Integrated Planning Model (IPM)[10,11] to project EGU emissions. The CAM_X modeling used these projected emissions to support the LTS for 2028 (SIP Guidance Steps 5 and 6).

Hawaiian Electric is willing to work with the DOH and EPA Region IX on an alternative to permit limits that relies on the State's RPS goals. The State of Hawaiʻi apparently contemplated that both the RPS and GHG emissions cap could be used to show reasonable progress in the 2018 Western States Planning Readiness Survey For Regional Haze State Implementation Plans For The Second Implementation Period Survey Results And Discussion (Readiness Survey)[12].

The Readiness Survey that was conducted by the Western Regional Air Partnership (WRAP) states:

> *Hawaiian Electric plans to use Hawaiʻi's existing Renewable Portfolio Standard (RPS) as a measure to make reasonable progress. The RPS ultimately requires the Hawaiian Electric Company to establish 100% renewable energy sales by 2045 to reduce fossil fuel consumption for mitigating GHGs. Mitigating GHGs will also reduce pollutants that impair visibility as a co-benefit. Hawaiian Electric Companies' Power Supply Improvement Plan (PSIP) provides future plans for the utility and independent power producers to achieve 100% RPS by 2045. The PSIP may be used to establish permit conditions to limit the emissions of pollutants that impair visibility for meeting reasonable progress goals. In accordance with our Hawaiʻi Administrative Rules (HAR), point sources are subject to a GHG emission cap to ensure emissions from stationary sources (both minor and major) return to 1990 GHG levels by 2020. The GHG emissions cap must be at least 16% below the baseline level unless the affected facility demonstrates that a 16% reduction is unattainable.*

Although based on the analysis herein, we do not believe that permit conditions are required to use the RPS to show progress, nor is it practical to do so given the difficulty in predicting the specifics of the RPS progress. However, Hawaiian Electric intends to provide a further analysis that may include additional strategies to include these two programs in its updated four-factor analysis report.

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[9] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period, page 17, August 2019, EPA-457/B-19-003. https://www.epa.gov/visibility/guidance-regional-haze-state-implementation-plans-second-implementation-period

[10] Technical Support Document for EPA's Updated 2028 Regional Haze Modeling, pages 11-12, September 2019. https://www.epa.gov/sites/production/files/2019-10/documents/updated_2028_regional_haze_modeling-tsd-2019_0.pdf

[11] Power Sector Modeling Platform v6 November 2018. https://www.epa.gov/airmarkets/power-sector-modeling-platform-v6-november-2018

[12] 2018 (final 1/2019) Western States Planning Readiness Survey For Regional Haze State Implementation Plans For The Second Implementation Period Survey Results And Discussion. https://www.wrapair2.org/pdf/WRAP%202018%20RH%20Planning%20Readiness%20Survey%20-%20Synthesis%20Report%20FINAL%20(including%20figures%20and%20attachments).PDF

Revised Four – Factor Analysis

REGIONAL HAZE FOUR-FACTOR ANALYSIS
Maalaea Generating Station

Hawaiian Electric

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1. EXECUTIVE SUMMARY

The State of Hawaiʻi has two Class I areas (National Parks) that trigger compliance with the Regional Haze Rule (RHR): Hawaiʻi's Mandatory Federal Class I Areas are Haleakalā National Park on Maui and Hawaiʻi Volcanoes National Park on the Hawaiʻi Island. This report documents the results of the RHR second planning period four-factor analysis conducted by Trinity Consultants (Trinity) on behalf of Hawaiian Electric[1] for the generating units at the Maalaea Generating Station (Maalaea). Maalaea contains:

- Five 2.5 megawatt (MW) diesel engine generators (M1, M2, M3, X1, and X2) currently firing ultra-low sulfur diesel (ULSD);
- Six 5.9 MW diesel engine generators (M4, M5, M6, M7, M8, and M9) currently firing diesel with a maximum sulfur content of 0.4 percent by weight;
- Four 12.5 MW diesel engine generators (M10, M11, M12, and M13) currently firing diesel with a maximum sulfur content of 0.4 percent by weight; and
- Four 20 MW combustion turbine generators (M14, M16, M17, and M19) currently firing diesel with a maximum sulfur content of 0.4 percent by weight.

Also, Appendix B and Appendix C contain analyses performed by AECOM Technical Services, Inc. (AECOM) of a fifth factor that includes a review of visibility impacts.

This report addresses the options that could be considered that have the potential to lower emissions and show reasonable progress toward the RHR goals. The conclusion of the four-factor analysis herein is consistent with the conclusions reached for the first planning period Best Available Retrofit Technology (BART) five-factor analysis for Kahului and Kanoelehua-Hill. Other long-term emissions reduction strategies, such as those included as part of Hawaiʻi's Renewable Portfolio Standards (RPS), the Hawaiian Electric Partnership Greenhouse Gas Emissions Reduction Plan (GHG ERP) required by Act 234 and the associated State of Hawaiʻi Department of Health (DOH) GHG Emissions Regulations (Hawaii Administrative Rules Title 11, Chapter 60.1, Subchapter 11) which require State enforceable GHG emissions limits, and Hawaiʻi's Energy Efficiency Portfolio Standard (EEPS), are viable alternatives to emission reductions from add-on controls and changes in the method of operations.

Hawaiian Electric and AECOM met with the DOH on February 12, 2020 to present special circumstances that apply in Hawaiʻi that should be given consideration in the development of the Hawaiʻi Regional Haze State Implementation Plan (SIP). Significant among those circumstances is Hawaiʻi's Statutory RPS which have put the state on a timetable to accomplish the same goals as the RHR twenty (20) years before the actual Regional Haze 2064 target date. These same issues were addressed by the U.S. Environmental Protection Agency (EPA) in the Federal Implementation Plan (FIP) and the DOH in its Progress Report[2] that was approved by the EPA effective on September 11, 2019. These special considerations are discussed further in Appendix B and Appendix C to this report.

Based on the four-factor analysis, and the materials set forth in the appendices, Hawaiian Electric does not propose any emissions reduction measures in addition to the Hawaiʻi RPS, EEPS, and the GHG ERP to meet the RHR requirements.

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[1] Hawaiian Electric" or the "Company" refers to Hawaiian Electric Company, Inc. (or "HE"), Hawaiʻi Electric Light Company, Inc. (or "HL") and/or Maui Electric Company, Limited (or "ME"). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

[2] 5-Year Regional Haze Progress Report for Federal Implementation Plan, HawaiʻI State Department of Health, October 2017, EPA-R09-OAR-2018-0744-0004.

2. BACKGROUND AND ADDITIONAL FACTORS

2.1. REGIONAL HAZE RULE BACKGROUND

In the 1977 amendments to the federal Clean Air Act (CAA), the U.S. Congress set a nation-wide goal to restore national parks and wilderness areas to natural visibility conditions by remedying existing, anthropogenic visibility impairment and preventing future impairments. On July 1, 1999, the EPA published the final RHR (40 CFR Part 51, Subpart P). The objective of the RHR is to restore visibility to natural conditions in 156 specific areas across the United States, known as Federal Class I areas. The CAA defines Class I areas as certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres)[3], and international parks that were in existence on August 7, 1977.

The RHR requires states to set goals that provide for reasonable progress towards achieving natural visibility conditions for each Class I area in their jurisdiction. In establishing a reasonable progress goal for a Class I area, each state must:

> *(A) Consider the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected sources, and include a demonstration showing how these factors were taken into consideration in selecting the goal. 40 CFR 51. 308(d)(1)(i)(A).* This is known as a four-factor analysis.
>
> *(B) Analyze and determine the rate of progress needed to attain natural visibility conditions by the year 2064. To calculate this rate of progress, the State must compare baseline visibility conditions to natural visibility conditions in the mandatory Federal Class I area and determine the uniform rate of visibility improvement (measured in deciviews) that would need to be maintained during each implementation period in order to attain natural visibility conditions by 2064. In establishing the reasonable progress goal, the State must consider the uniform rate of improvement in visibility and the emission reduction. 40 CFR 51. 308(d)(1)(i)(B).* The uniform rate of progress or improvement is sometimes referred to as the glidepath and is part of the state's Long Term Strategy (LTS).

During the first implementation period the EPA issued a FIP (77 FR 61478, October 9, 2012; see also *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii Air Division* U.S. EPA Region 9, May 14, 2012) which determined for the first planning period that NO_X was not contributing to regional haze significantly as to require control measures, and that the Oahu sources were not significantly contributing to regional haze. Additionally, as part of the EPA's decision with respect to BART controls, the EPA took into account that controls would result in "unduly increasing electricity rates in Hawaii." (see 77 FR 31707, May 29, 2012).

The control measures that were imposed during the first RHR implementation period established an emissions cap of 3,550 tons of SO_2 per year from the fuel oil-fired boilers at Hawaiʻi Electric Light's Hill, Shipman and Puna generating stations, beginning in January 1, 2018, at an estimated cost of 7.9 million dollars per year. According to the FIP, this represents a reduction of 1,400 tons per year from the total projected 2018 annual emissions of SO_2 from these facilities. This control measure, in conjunction with SO_2 and NO_X emissions control requirements that are already in place, was found to ensure that reasonable progress is made during this first planning period toward the national goal of no anthropogenic visibility impairment by 2064 at Hawaiʻi's two Class I areas.

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[3] The Class I areas in the state of Hawaiʻi include the Hawaiʻi Volcanoes National Park on the Hawaiʻi Island, and Haleakalā National Park on Maui.

The second implementation planning period (2019-2028) for the national regional haze efforts is currently underway. The EPA's *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period* (SIP Guidance)[4] provides guidance for the development of the implementation plans. There are a few key distinctions from the processes that took place during the first planning period (2004-2018). Most notably, the second planning period analysis distinguishes between natural (or "biogenic") and manmade (or "anthropogenic") sources of emissions. The EPA's *Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program* (Visibility Guidance)[5] provides guidance to states on methods for selecting the twenty (20) percent most impaired days to track visibility and determining natural visibility conditions. The approach described in this guidance document does not expressly attempt to account for haze formed from natural volcanic emissions; however, the 2017 RHR defines visibility impairment or anthropogenic visibility impairment as:

> *any humanly perceptible difference due to air pollution from anthropogenic sources between actual visibility and natural visibility on one or more days. Because natural visibility can only be estimated or inferred, visibility impairment also is estimated or inferred rather than directly measured.*

Specifically, the EPA's Visibility Guidance states that although they did not attempt to account for haze formed by natural volcanic emissions:

> *We encourage states with Class I areas affected by volcanic emissions to work with their EPA Regional office to determine an appropriate approach for determining which days are the 20 percent most anthropogenically impaired days.*

In the *5-Year Regional Haze Progress Report for Federal Implementation Plan,*[6] the DOH acknowledges the impact of SO_2 from the Kilauea volcano with the following statement:

> *A majority of the visibility degradation is due to the ongoing release of SO_2 from Kilauea volcano with emissions that vary by hundreds of thousands of tons from one year to another. Visibility improvement from significant reductions in Maui and Hawaii Island point source SO_2 is obscured by sulfate from natural volcanic SO_2 that overwhelms sulfate from anthropogenic SO_2 sources.*

Step 1 of the EPA's SIP Guidance is to identify the twenty (20) percent most anthropogenically impaired days and the twenty (20) percent clearest days and determine baseline, current, and natural visibility conditions for each Class I area within the state (40 CFR 51.308(f)(1)). Hawaiian Electric has concerns that this key step may not be accounted for during the second implementation planning period and the development of Hawaiʻi's RHR SIP. The identification of the twenty (20) percent most impaired days sets the foundation for identifying any needed emissions reductions.

Pursuant to 40 CFR 51.308(d)(3)(iv), the states are responsible for identifying the sources that contribute to the most impaired days in the Class I areas. To accomplish this, the Western Regional Air Partnership (WRAP), with Ramboll US Corporation, reviewed the 2014 National Emissions Inventory (NEI) and assessed each facility's impact on visibility in Class I areas with a "Q/d" analysis, where "Q" is the magnitude of emissions that impact ambient visibility and "d" is the distance of a facility to a Class I area. The WRAP Guidance itself states that the EPA has concerns over only relying on the Q/d method for screening sources. The EPA points out that the Q/d metric is only a rough indicator of actual visibility

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[4] US EPA Memorandum, "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period August 20, 2019, https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

[5] US EPA Memorandum, "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program", Dec. 20, 2019, Page 6 https://www.epa.gov/sites/production/files/2018-12/documents/technical_guidance_tracking_visibility_progress.pdf.

[6] 5-Year Regional Haze Progress Report for Federal Implementation Plan, Hawaiʻi State Department of Health, October 2017, EPA-R09-OAR-2018-0744-0004.

impact because it does not consider transport direction/pathway and dispersion and photochemical processes. To address the EPA's concern, the WRAP subcommittee recommends a second step, application of the weighted emissions potential analysis (WEP), which has not been done.[7] On September 11, 2019, the DOH informed Hawaiian Electric that its Maalaea Generating Station (Maalaea), among others, was identified, based on the Q/d analysis, as one of the sources potentially contributing to regional haze at the Haleakalā National Park and Volcanoes National Park. This report responds to the DOH September 2019 request to Hawaiian Electric to submit a four-factor analysis for Maalaea.

The SIP Guidance requires that the selection of sources and controls necessary to make reasonable progress must, in addition to the statutory four factors (cost, remaining useful life, etc.), also consider the five required factors listed in 40 CFR section 51.308(f)(2)(iv), and other factors that are reasonable to consider.[8] These additional factors include consideration of emissions reductions due to ongoing air pollution control programs and the anticipated net effect on visibility due to projected changes in source emissions. The Hawaiian Electric and AECOM prepared summary, included in Section 2.2, describes special circumstances applicable in Hawaiʻi that should be considered during the development of the Hawaiʻi Regional Haze SIP.

2.2. ADDITIONAL FACTORS

Hawaiian Electric and AECOM met with the DOH on February 12, 2020 to present special circumstances applicable in Hawaiʻi that should be considered during the development of the Hawaiʻi Regional Haze SIP. Significant among those circumstances is Hawaiʻi's Statutory RPS which have put the state on a timetable to accomplish the same goals as the RHR twenty years before the Regional Haze 2064 target date. These same issues were addressed by the EPA in the FIP and the DOH in its Progress Report that was approved by the EPA, effective on September 11, 2019. These special considerations are discussed further in Appendix B and Appendix C to this report and summarized in the following sections.

2.2.1. Lack of Contribution to Visibility Impairment Due to Prevailing Winds

As noted above, the DOH did not consider actual contribution to visibility impairment when selecting sources for the Four-Factor Analysis, but this is a critical factor in establishing realistic reasonable progress goals for Class I areas. The EPA's FIP for Hawaiʻi for the First Decadal Review (77 FR 61478, October 9, 2012) has already acknowledged the predominant trade winds in Hawaiʻi and thus, did not require controls on upwind sources (i.e., sources on Oahu and Maui).

The wind rose for the Kahului airport on Maui shows that the wind is almost always from the northeast and rarely blows from the west or northwest, the directions that could cause emissions from Maalaea to blow toward either of Hawaiʻi's Class I areas. The Kahului airport wind rose plot is provided below as Figure 2-1. Based on the infrequent wind blows from Maalaea toward either of Hawaiʻi's Class I areas, it is unlikely that the facility's emissions impact visibility at either Haleakalā National Park or Volcanoes National Park. Therefore, when balancing retrofit costs and visibility improvements, the DOH should consider the fact that emissions from this facility are unlikely to contribute to regional haze at Haleakalā National Park and Volcanoes National Park and as such additional emission reduction measures will have no impact on a showing of further reasonable progress.

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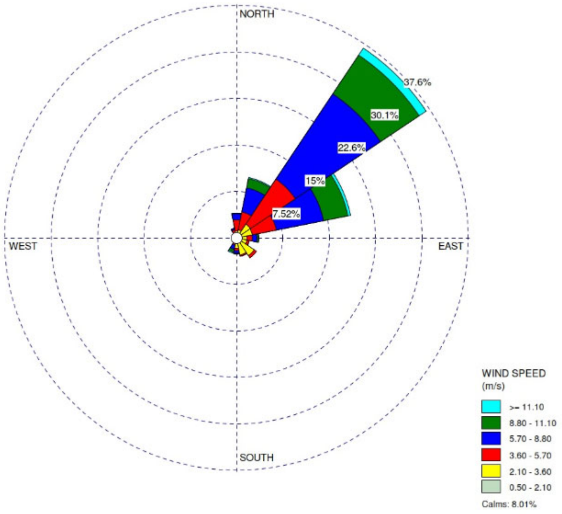
[7] WRAP Reasonable Progress Source Identification and Analysis Protocol for Second 10-year Regional Haze State Implementation Plans, dated February 27, 2019. (https://www.wrapair2.org/pdf/final%20WRAP%20Reasonable%20Progress%20Source%20Identification%20and%20Analysis%20Protocol-Feb27-2019.pdf)

[8] US EPA Memorandum, "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program", December 20, 2018, pp. 9, 21, C-1.

Figure 2-1. Kahului Wind Rose (2015 – 2019) Predominant Wind from the Northeast



2.2.2. Lack of Contribution to Visibility Impairment Due to Warm Weather Conditions

The potential for the formation of haze due to NO_X emissions is very low in Hawai‘i because of the warm weather conditions year round. Nitrate haze composition analyses for the Haleakalā and Hawai‘i Volcanoes National Parks from the IMPROVE web site are included in Appendix B to this report. The data for both national parks shows that the contribution of nitrates to haze is very low. It is low as a percentage of the total haze composition, but it is also low as an absolute value for light extinction (visibility impairment). The minimal impact of nitrate haze is clearly illustrated in the Hawai‘i Volcanoes National Parks monitoring data and is much lower than found at many monitors in other Class I areas around the country. This is in large part due to the unique chemistry of nitrate haze which is discussed further in Appendix B to this report.

Due to the low haze impact of NO_X, the DOH should not consider NO_X controls for the Second Decadal Review for Maalaea. A similar conclusion was reached during the First Decadal Review, for which the EPA did not consider NO_X controls to be material.

2.2.3. Contribution to Visibility Impairment from Volcanic Activity

Volcanic activity on the Hawai‘i Island represents a unique challenge to understanding haze in Hawai‘i Class I areas. The Kilauea volcano on Hawai‘i Island has been active for several years, and the levels of SO_2 emissions are being monitored by the United States Geological Survey. In addition to volcanoes being large sources of SO_2, they also emit significant amounts of NO_X. Volcanic activity on Hawai‘i Island is by far the largest source of both SO_2 and NO_X in the state and dominates visibility impairment to Class I areas as to completely obscure any small impact from anthropogenic sources. Significant portions of direct Particulate Matter (PM) emissions are due to volcanic activity. Any minimal impact of SO_2, NO_X, and PM emissions from power plants are projected to be eliminated well before the end point of the Regional Haze Rule (i.e., 2064) by Hawai‘i's Statutory RPS. Thus, the DOH should not consider SO_2, NO_X, or PM controls for the Second Decadal Period Review for Maalaea.

2.2.4. Renewable Portfolio Standards

For the reasons stated above and based on AECOM's analysis, *Appendix C: Hawaiʻi's Renewable Portfolio Standards Contribution to Regional Haze Progress*, SO_2, NO_X, and particulate matter, 10 microns or less in diameter (PM_{10}) emissions from Maalaea do not significantly contribute to regional haze at the Class I areas. The low impact that Maalaea may have on haze is already being reduced through conversion of electric generation to renewable energy sources as mandated by the RPS (Hawaiʻi Revised Statute (HRS) §269-92) and consistent with the Hawaiʻi Clean Energy Initiative (HCEI). Both past and projected future decreases in fossil-fueled electric generating unit (EGU) usage are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the RHR. The RPS will substantially reduce emissions of haze precursors (especially SO_2) by 2045. Therefore, further requirements for controls would not affect the showing of further progress under the RHR and, thus, are not needed at this time. This is further discussed in Appendix C to this report. Although RPS is listed as a control measure (which is consistent with the Hawaiʻi Progress Report for Phase 1), it was not necessary to review the RPS in the context of the four-factor analysis as these measures are already planned for implementation and although there are additional costs, they are inherent in the RPS program.

3. SULFUR DIOXIDE FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that SO_2 emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 3-1 lists the 2017 annual average fuel property data and fuel usage rates that were used in the control costing calculations and the baseline SO_2 emissions for the Maalaea units.

Table 3-1. 2017 Fuel Property Data and Usage and Baseline SO_2 Emissions

		2017 Annual Average Fuel Properties [A]			Annual Fuel Usage [B]		SO_2 Emissions	
Unit	**Primary Fuel**	**Sulfur Content**	**HHV (Btu/gal)**	**Density (lb/gal)**	**Volume (gal/yr)**	**Heat Input (MMBtu/yr)**	**(lb/MMBtu) [C]**	**(TPY) [D]**
M1	ULSD	0.0005%	137,934	7.04	45,180	6,232	4.71E-04	1.47E-03
M2	ULSD	0.0005%	137,934	7.04	26,309	3,629	4.71E-04	8.54E-04
M3	ULSD	0.0005%	137,934	7.04	45,123	6,224	4.71E-04	1.46E-03
M4	Diesel	0.0567%	137,169	6.97	368,268	50,515	0.0576	1.5
M5	Diesel	0.0567%	137,169	6.97	280,704	38,504	0.1039	2.0
M6	Diesel	0.0567%	137,169	6.97	278,524	38,205	0.0576	1.1
M7	Diesel	0.0567%	137,169	6.97	313,927	43,061	0.0975	2.1
M8	Diesel	0.0567%	137,169	6.97	279,114	38,286	0.0576	1.1
M9	Diesel	0.0567%	137,169	6.97	465,609	63,867	0.0576	1.8
M10	Diesel	0.0567%	137,169	6.97	2,933,686	402,410	0.0576	11.6
M11	Diesel	0.0567%	137,169	6.97	2,565,572	351,916	0.0576	10.1
M12	Diesel	0.0567%	137,169	6.97	2,882,514	395,391	0.0576	11.4
M13	Diesel	0.0567%	137,169	6.97	2,784,528	381,950	0.0576	11.0
X1	ULSD	0.0005%	137,934	7.04	47,215	6,513	0.0005	1.53E-03
X2	ULSD	0.0005%	137,934	7.04	47,455	6,546	0.0005	1.54E-03
M14	Diesel	0.0567%	137,169	6.97	8,037,944	1,102,554	0.0576	31.7
M16	Diesel	0.0567%	137,169	6.97	9,394,316	1,288,606	0.0576	37.1
M17	Diesel	0.0567%	137,169	6.97	8,435,032	1,157,022	0.1017	58.8
M19	Diesel	0.0567%	137,169	6.97	7,612,681	1,044,222	0.1031	53.8
							Total	**235.2**

[A] Calendar year 2017 annual average fuel properties from company records.

[B] Calendar annual fuel usage from company records.

[C] The SO_2 emission factors for units M1-M4, M6, M8-M16 and X1 and X2 are based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average fuel density (7.04 lb/gal for ULSD; 6.97 lb/gal for diesel) and higher heating value (137,933 Btu/gal for ULSD; 137,169 Btu/gal for diesel). The SO_2 emission factors for units M5, M7, M17 and M19 are based the monthly reported emissions on the 2017 Annual Emissions Report Forms; Diesel Engine Generators Units M5 and M7 and Combustion Turbine Generators Units M17 and M19.

[D] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Diesel engine generators M1, M2, M3, X1, and X2 currently burn Ultra Low Sulfur Diesel (ULSD); thus, a four-factor analysis for these units is not required for SO_2. A four-factor analysis for the remaining units, M4 through M19 was conducted.

3.1. SULFUR DIOXIDE CONTROL OPTIONS

The characterization of emission controls available and applicable to the source is a necessary step before the four factors can be analyzed. SO_2 emissions are generated during fuel oil combustion from the oxidation of sulfur contained in the fuel. Available SO_2 control technologies are:

- Flue Gas Desulfurization (FGD) systems
    - Dry Sorbent Injection (DSI)
    - Spray Dryer Absorber (SDA)
    - Wet Scrubber
    - Circulating Dry Scrubber (CDS)
- Fuel Switching to a lower sulfur content distillate fuel
- Renewable Portfolio Standards (RPS)

The feasibility of these controls is discussed in the following sections.

3.1.1. Post-Combustion Controls

FGD applications have not been used historically for SO_2 control from diesel engines generators and combustion turbines generators. There are no known FGD applications for similar diesel engines and combustion turbines and the performance of FGDs on diesel engines generators and combustion turbines generators is unknown. The EPA took this into account when evaluating the Best Available Retrofit Technology (BART) presumptive SO_2 emission rate for oil-fired units and determined that the presumptive emission rate should be based on the sulfur content of the fuel oil, rather than on FGD[9]. Since there are no applications of FGD on diesel engine generators and combustion turbine generators in the U.S., FGD is considered technically infeasible for the control of SO_2 from the Maalaea diesel engine generators and combustion turbine generators.

3.1.2. Fuel Switching

The Maalaea diesel engine generators (M4 through M13) and combustion turbine generators (M14, M16, M17, and M19) currently burn diesel with a maximum sulfur content of 0.4 percent by weight. The average sulfur content of the diesel burned in 2017 was approximately 0.0567 percent by weight. Switching to a lower sulfur fuel would reduce SO_2 emissions in proportion to the reduction in fuel sulfur content.[10] ULSD has a maximum sulfur content of 0.0015 percent by weight and is available and a technically feasible option. The SO_2 four-factor analysis evaluates the Maalaea diesel engine generators and combustion turbine generators switching to ULSD.

3.1.3. Renewable Portfolio Standards

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that SO_2 emissions from Maalaea do not significantly contribute to regional haze. The small impact that Maalaea may have on haze is already being reduced through conversion of electric generation to renewable energy sources as mandated by the RPS (Hawai'i Revised Statute (HRS) §269-92) and consistent with the HCEI. Both past and projected future decreases in fossil-fueled EGU usage are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the RHR. The RPS will substantially reduce emissions of haze precursors (especially SO_2) by 2045. Therefore, further requirements for controls would not affect the showing of further progress under the RHR and, thus, are not needed at this time. This is further discussed in Appendix C to this report. Although RPS is listed as a control measure (which is consistent with the Hawai'i Progress Report for Phase 1), it was not necessary to review the RPS in the context of the four-factor analysis as these measures are already planned for implementation and although there are additional costs, they are inherent in the RPS program.

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[9] *Summary of Comments and Responses on the 2004 and 2001 Proposed Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations* EPA Docket Number OAR-2002-0076.

[10] Natural gas has less sulfur than the existing residual fuel oil. However, natural gas is not a technically feasible option because there is no utility-scale natural gas supply in Hawai'i.

3.2. FOUR-FACTOR ANALYSIS

As discussed above, fuel switching to a ULSD is the only feasible option to reduce SO_2 emissions. For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for switching to a ULSD are discussed in the following sections.

3.2.1. Cost of Compliance

The cost effectiveness of the fuel switching was determined by calculating the annual incremental cost of switching to ULSD divided by the reduction in SO_2 emissions. Maalaea currently obtains diesel from local suppliers; current fuel costs are provided in Appendix D. The fuels are refined on Oahu and changes in quantities of ULSD would require new contracts with fuel suppliers. This adds a level of uncertainty to the cost of compliance. Par Hawaii is the only refinery in Hawaiʻi and is near its production capacity of ULSD. Therefore, increases in ULSD use would require importing ULSD to Hawaiʻi and for parity the price of diesel with a maximum sulfur content of 0.4 percent by weight is based on importing diesel to Hawaiʻi. Appendix D contains the estimated cost of importing ULSD and diesel to Hawaiʻi.

Table 3-2 presents a summary of the cost effectiveness of switching to ULSD with a maximum sulfur content of 0.0015 percent by weight. The cost effectiveness is determined by dividing the annual cost increase in fuel by the annual reduction in SO_2 emissions. The cost effectiveness of switching to ULSD is \$10,357 per ton of SO_2 and will increase the Maalaea fuel cost by 1.85 million dollars (\$1,850,000) annually and 37 million dollars (\$37,0000,000) over twenty (20) years.

3.2.2. Time Necessary to Achieve Compliance

If the DOH determines that switching to ULSD is needed to achieve reasonable progress, it is anticipated that this change would take two to three years to implement because of several factors: 1) Although not entirely under its control, Hawaiian Electric generally requests that the State of Hawaiʻi Public Utilities Commission (Commission) approve fuel contracts and issue its Decision and Order within one year following the filing of the application to the Commission; 2) Hawaiian Electric needs to go through a formal process to request bids from fuel suppliers; 3) Negotiations with the fuel supplier can take up to four months; 4) The schedule for any required infrastructure modifications are dependent on the extent on the required changes; 5) If fuel switching is required at other Hawaiian Electric facilities, the type of fuel to be used for replacement, the effect on the fuel supply, and ability of the local refinery to accommodate the change may be significantly impacted; and 6) Imported fuel may be required if there is a lack of local supply.

3.2.3. Energy and Non-Air Quality Environmental Impacts

There are no energy and non-air quality environmental impacts of compliance for fuel switching. The cost increase associated with fuel switching to a lower sulfur fuel will increase the cost of the electricity produced by Maalaea. This increase will impact the price of electricity for Maui Electric customers. This is an important cost to the community that must be considered. Hawaiian Electric encourages the DOH to use the flexibility in the EPA's SIP guidance[11] in the selection of control measures necessary to make

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[11] *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period*, August 2019, EPA-457/B-19-003.

reasonable progress and to consider additional factors when developing the long-term strategy to improve visibility at Class I areas. Also, given the fragile condition of the state's fuel supply and Hawaiian Electric's position as a major customer in the state's fuel market, a fuel supply change could have sweeping effects on the island's fuel market that may not be apparent from the cost estimates associated with Hawaiian Electric such as the ability of the local refinery to accommodate the change and potential need for imported fuel.

3.2.4. Remaining Useful Life

The cost of compliance does not contain any capital costs. Therefore, the remaining useful lives of the Maalaea diesel engine generators and combustion turbine generators are not needed to annualize the capital cost.

3.3. SULFUR DIOXIDE CONCLUSION

The cost effectiveness of switching to ULSD with a maximum sulfur content of 0.0015 percent by weight for M4 through M19 is $10,300 per ton of SO2 and would increase the fuel cost by $1.85 million ($1,850,000) annually and 37 million dollars ($37,0000,000) over twenty (20) years. These costs are greater than the BART and reasonable progress thresholds established in the first planning period of $5,600 per ton and $5,500 per ton, respectively.[12] Thus, no fuel changes or add-on controls are proposed for Maalaea.

While there are no fuel changes or add-on controls proposed, other long- term emissions reduction strategies, such as those included as part of the Hawai'i RPS, EEPS, and the GHG ERP, are viable alternatives that would create greater benefits and allow for the demonstration of reasonable progress.

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[12] *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawai'i*, U.S. EPA Region 9, May 14, 2012.

Table 3-2. SO_2 Cost Effectiveness of Switching to ULSD

Unit	Current Diesel (0.4% Maximum Sulfur) [A]					ULSD (0.0015% maximum Sulfur) [B]						
	2017 Average Sulfur Content	Fuel Heating Value (HHV) (Btu/gal)	Annual Fuel Usage (gal/yr)	2017 Annual Heat Input (MMBtu/yr)	2017 SO_2 Emissions [C] (tpy)	Fuel Heating Value (HHV) (Btu/gal)	Annual Fuel Usage (gal/yr)	Controlled SO_2 Emissions (tpy)	SO_2 Reduced (tpy)	Fuel Cost Differential [D] ($/Gal)	Fuel Cost Differential [D] ($/yr)	SO_2 Cost Effectiveness ($/ton)
M4	0.0567%	137,169	368,268	50,515	1.5	137,934	366,225	0.04	1.42	0.04	14,649	10,347
M5	0.0567%	137,169	280,704	38,504	1.1	137,934	279,147	0.03	1.08	0.04	11,166	10,347
M6	0.0567%	137,169	278,524	38,205	1.1	137,934	276,979	0.03	1.07	0.04	11,079	10,347
M7	0.0567%	137,169	313,927	43,061	1.2	137,934	312,185	0.03	1.21	0.04	12,487	10,347
M8	0.0567%	137,169	279,114	38,286	1.1	137,934	277,566	0.03	1.07	0.04	11,103	10,347
M9	0.0567%	137,169	465,609	63,867	1.8	137,934	463,026	0.05	1.79	0.04	18,521	10,347
M10	0.0567%	137,169	2,933,686	402,410	11.6	137,934	2,917,409	0.31	11.28	0.04	116,696	10,347
M11	0.0567%	137,169	2,565,572	351,916	10.1	137,934	2,551,338	0.27	9.86	0.04	102,054	10,347
M12	0.0567%	137,169	2,882,514	395,391	11.4	137,934	2,866,521	0.30	11.08	0.04	114,661	10,347
M13	0.0567%	137,169	2,784,528	381,950	11.0	137,934	2,769,078	0.29	10.71	0.04	110,763	10,347
M14	0.0567%	137,169	8,037,944	1,102,554	31.7	137,934	7,993,347	0.84	30.90	0.04	319,734	10,347
M16	0.0567%	137,169	9,394,316	1,288,606	37.1	137,934	9,342,193	0.99	36.12	0.04	373,688	10,347
M17	0.0567%	137,169	8,435,032	1,157,022	33.3	137,934	8,388,232	0.89	32.43	0.04	335,529	10,347
M19	0.0567%	137,169	7,612,681	1,044,222	30.1	137,934	7,570,443	0.80	29.27	0.04	302,818	10,347

[A] Based on 2017 average fuel properties and fuel usage.

[B] Based on 2017 average HHV and density for ULSD and contract fuel sulfur limit.

[C] The listed annual SO_2 emissions from M5, M7, M17, and M19 are based on based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average diesel fuel density (6.97 lb/gal) and higher heating value (137,169). The listed 2017 annual SO_2 emissions from the remaining units are from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[D] See Appendix D for fuel cost.

4. NITROGEN OXIDES FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that NO_X emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 4-1 lists the baseline NO_X emissions for Maalaea.

Table 4-1. Baseline NO_X Emissions

Unit	NO_X Emissions (lb/MMBtu) [A]	NO_X Emissions (TPY) [B]
M1	3.200	10.0
M2	3.200	5.8
M3	3.200	10.0
M4	3.200	80.8
M5	4.296	82.7
M6	3.200	61.1
M7	5.708	122.9
M8	3.200	61.3
M9	3.200	102.2
M10	2.884	580.3
M11	2.877	506.2
M12	2.027	405.9
M13	2.171	419.5
X1	1.586	5.2
X2	1.614	5.3
M14	0.155	85.4
M16	0.153	98.6
M17	0.133	76.7
M19	0.127	66.4
	Total	**2,786.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

4.1. NITROGEN OXIDES CONTROL OPTIONS

The characterization of emission controls available and applicable to the source is a necessary step before the four factors can be analyzed. NO_X emissions are produced during fuel combustion when nitrogen contained in the fuel and combustion air is exposed to high temperatures. The origin of the nitrogen (i.e., fuel versus combustion air) has led to the use of the terms "thermal NO_X" and "fuel NO_X". Thermal NO_X emissions are produced when high combustion temperatures oxidize elemental nitrogen in the combustion air. Fuel NO_X emissions are created by the oxidation of nitrogen contained in the fuel.

Thermal NO_X emissions are the primary source of NO_X emissions from the Maalaea diesel engine generators and combustion turbine generators.

4.1.1. Diesel Engine Generators

Available diesel engine generators NO_X control technologies are:

- Fuel Ignition Timing Retard (FITR) and Combustion Improvements
- Selective Non-Catalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

The feasibility of these controls is discussed in the following sections.

4.1.1.1. Fuel Ignition Timing Retard and Combustion Improvements

FITR reduces the NO_X emissions by retarding the fuel injection timing causing more combustion to occur during the expansion stroke. This effectively lowers the peak combustion temperatures and pressures and reduces NO_X formation.

- Units M1, M2, M3, X1, and X2 are Electro-Motive Diesels (EMD) Model No. 20-645, and units X1 and X2 use FITR to reduce NO_X emissions. Thus, the addition of FITR on units M1, M2, and M3 is a feasible option to reduce NO_X emissions.
- Units M4 through M7 are Cooper-Bessemer diesel engine generators. The original manufacturer was acquired by another service provider, Cooper Machinery Services, that was contacted and indicated that a standard FITR retrofit option is not available for Units M4 through M7 and it would cost up to four million ($4,000,000) dollars per engine for a custom solution. Thus, FITR is not a commercially available option for Units M4 through M7.
- Units M8 and M9 are Colt Industries diesel engine generators, a division of Fairbanks-Morse at the time of manufacture. Fairbanks-Morse, the current service provider, does not offer FITR for these units and would need to perform an engineering study to determine if FITR is feasible.
- Units M10 through M13 are Mitsubishi diesel engine generators. Units M12 and M13 use FITR to reduce NO_X emissions. M10 and M11 were manufactured in December 1978 and November 1979, respectively, ten (10) years before M12 and M13 were manufactured. The manufacturer was contacted and indicated that a FITR retrofit option is not available for Units M10 and M11. Thus, FITR is not a feasible option for Units M10 and M11.

4.1.1.2. Selective Non-Catalytic Reduction

SNCR is an add-on technology that reduces NO_X using ammonia or urea injection similar to SCR but operates at a higher temperature (1,600 degrees Fahrenheit (°F) to 2,200 °F). Since SNCR does not require a catalyst, this process is more attractive than SCR from an economic standpoint. The operating temperature window, however, is not compatible with diesel engine generator exhaust temperatures, which do not exceed 1,100°F.[13] Therefore, this technology is not technically feasible for the Maalaea diesel engine generators.

4.1.1.3. Selective Catalytic Reduction

SCR is a process in which NO_X in the exhaust gas (which is composed of both nitric oxide (NO) and NO_2) is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed selective because the ammonia preferentially reacts with NO_X rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions are:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

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[13] *Alternative Control Techniques Document - NO_X Emissions from Stationary Gas Turbines,* EPA-453/R-93-007, January 1993.

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

The SCR process requires a reactor, catalyst, ammonia storage, and an ammonia injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_X concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The estimated NO_X control range for SCR is ninety percent for the diesel engine generators. This control is a technically feasible option for the Maalaea diesel engine generators.

4.1.2. Combustion Turbine Generators

Potential NO_X control technologies for fuel oil-fired combustion turbine generators are:

- Dry Low NO_X (DLN) combustion design
- SNCR
- SCR

The feasibility of these controls is discussed in the following sections.

4.1.2.1. Dry Low NO_X Combustion Design

DLN is a gas-turbine combustion technology that enables gas-turbine combustors to produce low NO_X emission levels without diluents (such as water or steam) or catalysts. DLN technology utilizes a lean, premixed flame as opposed to a turbulent diffusion flame, therefore, requiring the use of natural gas or other gaseous fuels. Since diesel cannot be easily premixed, it is not suitable as a DLN fuel.[14] Therefore, this technology is not technically feasible for the Maalaea combustion turbine generators.

4.1.2.2. Selective Non-Catalytic Reduction

SNCR is an add-on technology that reduces NO_X using ammonia or urea injection similar to SCR but operates at a higher temperature (1,600°F to 2,200°F). Since SNCR does not require a catalyst, this process is more attractive than SCR from an economic standpoint. The operating temperature window, however, is not compatible with gas turbine exhaust temperatures, which do not exceed 1,100°F. Additionally, the residence time required for the reaction is approximately 100 milliseconds, which is relatively slow for gas turbine operating flow velocities.[15] Therefore, this technology is not technically feasible for the Maalaea combustion turbine generators.

4.1.2.3. Selective Catalytic Reduction

SCR refers to the process in which NO_X in the exhaust gas (which is composed of both NO and NO_2) is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed selective because the ammonia preferentially reacts with NO_X rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions are:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

The SCR process requires a reactor, catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_X concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. The four

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[14] *Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, Internal Combustion Engines Technologies & Cost Effectiveness*, Northeast States for Coordinated Air Use Management, December 2000.

[15] *Alternative Control Techniques Document - NO_X Emissions from Stationary Gas Turbines,* EPA-453/R-93-007, January 1993.

factors are addressed in Section 4.2. For this analysis, SCR is assumed to reduce NO_X emissions to fifteen parts per million by volume dry (ppmvd) at fifteen percent oxygen (O_2).

4.2. FOUR-FACTOR ANALYSIS

As discussed above, adding FITR to units M1, M2, and M3 and adding SCR for all units are the best feasible option to reduce NO_X emissions.

For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for adding FITR for units M1, M2, and M3 and SCR for all units are discussed in the following sections.

4.2.1. Cost of Compliance

For purposes of this four-factor analysis, the capital costs of adding FITR to units M1, M2 and M3 have been estimated based on vendor data. The cost effectiveness of FITR is based on a fifty percent reduction in NO_X emissions. Table 4-2 presents a summary of the cost effectiveness of adding FITR to units M1, M2 and M3. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions and is based on the ratio of the NO_X emissions factors listed in Table 4-1 for units M1, M2, and M3 (EMD Model No. 20-645 without FITR) to the emissions factors for units X1 and X2 (EMD Model No. 20-645 with FITR). The cost effectiveness of adding FITR to units M1, M2, and M3 ranges from $4,200 per ton to $7,200 per ton of NO_X and the total cost equals 60 thousand dollars ($60,000) annually and 1.2 million dollars ($1,200,000) over twenty (20) years.

For purposes of this four-factor analysis, the capital costs and annual operating costs of adding SCR to the Maalaea diesel engine generators have been estimated based on a combination of vendor data and generic EPA control costing[16]. Due to space constraints, new stacks equipped with catalyst housing are required. The cost effectiveness of SCR is based on a ninety percent reduction in NO_X emissions for the diesel engine generators. Table 4-3 presents a summary of the cost effectiveness of adding SCR to the Maalaea diesel engine generators. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions. The cost effectiveness of adding SCR to the Maalaea diesel engine generators ranges from $6,200 per ton to $33,900 per ton of NO_X and the total cost equals 22 million dollars ($22,000,000) annually and 440 million dollars ($440,000,000) over twenty (20) years. Appendix A contains the SCR costing details.

For purposes of this four-factor analysis, the capital costs and annual operating costs of adding SCR to the Maalaea combustion turbine generators have been estimated. The SCR costing is based on generic EPA control costing[17] which does not consider Hawaiʻi's remote location which results in additional shipping and higher construction cost. To account for these higher costs, a Maui construction cost multiplier[18] of 1.938 was applied to the SCR cost. Detailed engineering studies and vendor quotes are

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[16] *Assessment of Non-EGU NO_X Emission Controls, Cost of Controls, and Time for Compliance, Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS*. Docket ID No. EPA-HQ-OAR-2015-0500, November 2015.

[17] *Ibid*.

[18] The Maui construction cost multiplier is based on cost of construction geographical multipliers from the *RSMeans Mechanical Cost Data 2016* to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.

needed to refine the SCR costing. The process to obtain a vendor quote could take up to two (2) months. Additionally, an engineering study would be required to develop a design which could take up to two (2) months to complete with a cost of approximately $20,000. Due to cost and time constraints, a detailed engineering study cannot be provided at this time. The cost effectiveness of SCR is based on reducing NO_X emissions to fifteen ppmvd at fifteen percent O_2 which is the current permit limit for other GE LM2500 combustion turbines in Hawaiʻi and represents a proven level of control for these LM2500 combustion turbine generators . Table 4-4 presents a summary of the cost effectiveness of adding SCR to the Maalaea combustion turbine generators. The cost effectiveness is determined by dividing the annual cost by the annual reduction in NO_X emissions. The cost effectiveness of adding SCR to the Maalaea combustion turbine generators ranges from $52,300 per ton to $77,700 per ton of NO_X and the total cost equals 7.4 million dollars ($7,400,000) annually and 148 million dollars ($148,000,000) over twenty (20) years. Appendix A contains the SCR costing details.

4.2.2. Time Necessary to Achieve Compliance

If the DOH determines that controls are needed to achieve reasonable progress goals, it is anticipated that this change could be implemented in three to five years.

4.2.3. Energy and Non-Air Quality Environmental Impacts

SCR systems require electricity to operate the ancillary equipment. The need for electricity to help power some of the ancillary equipment creates a demand for energy that currently does not exist. SCR can potentially cause significant environmental impacts related to the storage of ammonia, and the storage of aqueous ammonia above 10,000 pounds is regulated by the EPA's Risk Management Program (RMP) because the accidental release of ammonia has the potential to cause serious injury and death to persons in the vicinity of the release. SCR will likely also cause the release of unreacted ammonia to the atmosphere. This is referred to as ammonia slip. Ammonia slip from SCR systems occurs either from ammonia injection at temperatures too low for effective reaction with NO_X, leading to an excess of unreacted ammonia, or from over-injection of reagent leading to uneven distribution, which also leads to an excess of unreacted ammonia. Ammonia released from SCR systems will react with sulfates and nitrates in the atmosphere to form ammonium sulfate and ammonium nitrate. Together, ammonium sulfate and ammonium nitrate are the predominant sources of regional haze.

4.2.4. Remaining Useful Life

The remaining useful lives of the Maalaea units do not impact the annualized capital costs of potential controls because the useful lives of the Maalaea units is assumed to be longer than the capital cost recovery period, which is twenty (20) years.

Table 4-2. NO_X Cost Effectiveness of FITR

	Design Nominal Output (MW)	Control Option	2017 NO_X Emissions [A] (tpy)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Cost [B] ($)	Capital Recovery Factor [C]	Annualized Capital Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.09	20,795	4,159
M2	2.5	FITR	5.8	50%	2.9	2.9	220,304	0.09	20,795	7,171
M3	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.09	20,795	4,159

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed capital cost is the total installed cost of an EMD Tier II Pack Update from a 2012 vendor quote. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]   CRF = 0.09   Where: I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

[D] Capital Cost x CRF

Table 4-3. NO_X Cost Effectiveness of SCR on the Maalaea Diesel Engine Generators

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 NO_X Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Recovery [B] ($)	Annual Operating Cost [C] ($)	Total Annualized Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	3,600	SCR	10.0	346.4	90%	1.0	9.0	124,691	49,755	174,446	19,383
M2	2.5	3,600	SCR	5.8	206.8	90%	0.6	5.2	124,691	29,703	154,395	29,578
M3	2.5	3,600	SCR	10.0	340.9	90%	1.0	9.0	124,691	48,965	173,656	19,295
M4	5.6	7,762	SCR	80.8	1,698.0	90%	8.1	72.7	279,309	525,853	805,161	11,072
M5	5.6	7,762	SCR	82.7	1,110.0	90%	8.3	74.4	279,309	343,755	623,064	8,371
M6	5.6	7,762	SCR	61.1	1,252.0	90%	6.1	55.0	279,309	387,731	667,040	12,130
M7	5.6	7,762	SCR	122.9	1,299.0	90%	12.3	110.6	279,309	402,287	681,595	6,162
M8	5.6	7,798	SCR	61.3	1,257.0	90%	6.1	55.2	279,309	391,085	670,394	12,151
M9	5.6	7,798	SCR	102.2	1,929.0	90%	10.2	92.0	279,309	600,162	879,470	9,562
M10	12.5	17,520	SCR	580.3	5,335.8	90%	58.0	522.3	623,457	3,729,808	4,353,265	8,335
M11	12.5	17,520	SCR	506.2	4,677.7	90%	50.6	455.6	623,457	3,269,786	3,893,242	8,546
M12	12.5	17,520	SCR	405.9	5,291.4	90%	40.6	365.3	623,457	3,698,772	4,322,228	11,832
M13	12.5	17,520	SCR	419.5	4,944.2	90%	42.0	377.6	623,457	3,456,073	4,079,530	10,805
X1	2.5	3,600	SCR	5.2	235.0	90%	0.5	4.7	124,691	33,754	158,445	33,856
X2	2.5	3,600	SCR	5.3	228.6	90%	0.5	4.8	124,691	32,835	157,526	33,024

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Capital recovery is based on a cost of $49,877 per MW based on an 2012 internal egneering report for units M5 - M9. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[C] Annual operating cost is based on a cost of $0.0399 per engine horsepower per operating hour based on EPA costing. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[D] Total Annualized Cost = Capital Recovery + Annual Operating Cost

Table 4-4. NO_X Cost Effectiveness of SCR Maalaea Combustion Turbine Generators

	Control Option	2017 NO_X Emissions [A] (tpy)	Controlled Emission Rate [B] (ppmvd @ 15% O_2)	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Annualized Cost [C] ($)	NO_X Cost Effectiveness ($/ton)
M14	SCR	85.4	15	54.9	30.5	1,842,606	60,413
M16	SCR	98.6	15	63.4	35.2	1,842,606	52,326
M17	SCR	76.7	15	49.3	27.4	1,842,606	67,266
M19	SCR	66.4	15	42.7	23.7	1,842,606	77,700

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Controlled emissions are based on the ratio of the permit limit of 42 ppmvd @ 15% O_2 to the listed controlled emission rate.

[C] The annual SCR cost is documented in Appendix A. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index.

4.3. NITROGEN OXIDES CONCLUSION

The cost effectiveness of adding FITR on units M1, M2, and M3 ranges from $4,200 per ton to $7,200 per ton of NO_X and the total cost equals 60 thousand dollars ($60,000) annually and 1.2 million dollars ($1,200,000) over twenty (20) years. The cost effectiveness of adding SCR to diesel engine generators M1 through M13, X1, and X2 ranges from $6,200 per ton to $33,900 per ton of NO_X and the total cost equals 22 million dollars ($22,000,000) annually and 440 million dollars ($440,000,000) over twenty (20) years. The cost effectiveness of adding SCR to combustion turbine generators M14, M16, M17, and M19 ranges from $52,300 per ton to $77,700 per ton of NO_X and the total cost equals 7 million dollars ($7,400,000) annually and 148 million dollars ($148,000,000) over twenty (20) years. These costs exceed the BART analyses conducted for the first planning period. For the first planning period, the EPA concluded that SCR was not cost effective.[19]

The results of the four-factor analysis are consistent with the conclusions, that NO_X controls are not required, reached for the first planning period. Therefore, Hawaiian Electric does not propose any NO_X emissions reduction measures in addition to the Hawai'i RPS, EEPS, and the GHG ERP to meet the RHR requirements.

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[19] *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawai'i*, U.S. EPA Region 9, May 14, 2012.

5. PARTICULATE MATTER FOUR-FACTOR ANALYSIS

AECOM's analysis, *Appendix C: Hawai'i's Renewable Portfolio Standards Contribution to Regional Haze Progress*, concluded that PM_{10} emissions from Maalaea do not significantly contribute to regional haze. Additionally, as also mentioned in *Appendix B: Hawaiian Electric Regional Haze Visibility Considerations*, Maalaea is not upwind of either of Hawai'i's Class I areas. The first step in the analysis is to establish a baseline for emissions. Per DOH's letter dated September 11, 2019, calendar year 2017 actual emissions are used to define the baseline emissions for the four-factor analysis. Table 5-1 lists the baseline PM_{10} emissions for Maalaea.

Table 5-1. Baseline PM_{10} Emissions

	PM_{10} Emissions	
Unit	**(lb/MMBtu)** [A]	**(TPY)** [B]
M1	0.0573	0.2
M2	0.0573	0.1
M3	0.0573	0.2
M4	0.0573	1.4
M5	0.0573	1.1
M6	0.0573	1.1
M7	0.0573	1.2
M8	0.0573	1.1
M9	0.0573	1.8
M10	0.0540	10.9
M11	0.0540	9.5
M12	0.0949	19.0
M13	0.0989	19.1
X1	0.0573	0.2
X2	0.0573	0.2
M14	0.0267	14.7
M16	0.0460	29.6
M17	0.0292	16.9
M19	0.0307	16.0
	Total	**144.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Diesel engine generators M1, M2, M3, X1, and X2 currently burn ULSD; thus, a four-factor analysis is not required for PM_{10}.

5.1. PARTICULATE MATTER CONTROL OPTIONS

The characterization of emission controls available and applicability to the source is a necessary step before the four factors can be analyzed. PM_{10} emissions from diesel engine generators and combustion turbine generators result from incomplete combustion and noncombustible trace constituents in the fuel. PM_{10} emissions are comprised of both "filterable" and "condensable" PM_{10}. Filterable PM_{10} is that portion of the total PM_{10} that exists in the stack in either solid or liquid state and can be measured on a filter. Condensable PM_{10} is that portion of the total PM_{10} that exists as a gas in the stack but condenses in the cooler ambient air to form particulate matter. Condensable PM_{10} is composed of organic and inorganic compounds and is generally considered to be less than 1.0 micrometers in aerodynamic diameter.

Units M4 through M7 are 4.9 MW Cooper-Bessemer LSV-20-T diesel engine generators and diesel particulate filters have been identified[20] as a possible control option for these diesel engine generators. Units M8 and M9 are 4.9 MW Colt Industries C-P PC2V diesel engine generators and cannot handle the additional backpressure[21]. A review of vendor data shows that diesel particulate filters are generally limited to diesel engine generator applications of less than 4 MW[22]. Units M10 through M13 have a nominal rating of 12.5 MW and the application of diesel particulate filters on units of this size has not been identified. Therefore, diesel particulate filters are not feasible options for units M8 through M13.

The EPA's BACT/RACT/LAER clearinghouse does not list any post-combustion PM_{10} controls for diesel-fired combustion turbine generators. PM_{10} emissions from combustion turbine generators are controlled by good combustion practices. Therefore, additional PM_{10} controls are not feasible options for combustion turbine generators M14, M16, M17, and M19.

5.2. FOUR-FACTOR ANALYSIS

As discussed above, adding diesel particulate filters to units M4 through M7 is the best feasible options to reduce PM_{10} emissions. For the second planning period, the focus is on determining reasonable progress through analyses of the four factors identified in Section 169A(g)(1) of the CAA:

1. The cost of compliance;
2. The time necessary to achieve compliance;
3. The energy and non-air quality environmental impact of compliance; and
4. The remaining useful life of any existing source subject to such requirements.

The four factors for adding diesel particulate filters to units M4 through M7 are discussed in the following sections.

5.2.1. Cost of Compliance

For purposes of this four-factor analysis, the incremental capital costs of adding diesel particulate filters the SCR systems addressed in Section 4.2 to units M4 through M7 has been estimated. The cost effectiveness of adding diesel particulate filters is based on an eighty-five percent reduction in PM_{10} emissions. Table 5-2 presents a summary of the cost effectiveness of adding diesel particulate filters to units M4 through M7. The cost effectiveness is determined by dividing the annual cost by the annual reduction in PM_{10} emissions. The cost effectiveness of adding diesel particle filters to units M4 through M7 ranges from \$41,200 per ton to \$52,500 per ton of PM_{10}. Appendix A contains the costing details.

5.2.2. Time Necessary to Achieve Compliance

If the DOH determines that controls are needed to achieve reasonable progress goals, it is anticipated that this change could be implemented in three to five years.

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[20] 2012 Internal Engineering Study provided as Attachment 5 of Hawaiian Electric's response to the DOH's comments submitted on August 14, 2020

[21] Ibid.

[22] https://www.miratechcorp.com/fa-content/uploads/2014/05/MIR-190904_LTR_Brochure_Update_092319.pdf.

Table 5-2. PM_{10} Cost Effectiveness of Diesel Particulate Filters

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 PM_{10} Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled PM_{10} Emissions (tpy)	PM_{10} Reduced (tpy)	Incremental Capital Cost [B] ($)	Capital Recovery Factor [C]	Incremental Annualized Capital Cost [D] ($)	PM_{10} Cost Effectiveness ($/ton)
M4	5.6	7,762	DPF	1.4	1,698.0	85%	0.2	1.2	519,586	0.09	49,045	41,214
M5	5.6	7,762	DPF	1.1	1,110.0	85%	0.2	0.9	519,586	0.09	49,045	52,455
M6	5.6	7,762	DPF	1.1	1,252.0	85%	0.2	0.9	519,586	0.09	49,045	52,455
M7	5.6	7,762	DPF	1.2	1,299.0	85%	0.2	1.0	519,586	0.09	49,045	48,084

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed incremental capital cost is based on the incremental capital cost of adding a DPF to the SCR installation. The SCR and SCR+DPF capital cost are from an 2012 internal engineering report for units M5 - M9. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.09 Where: I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

[D] Incremental Capital Cost x CRF

5.2.3. Energy and Non-Air Quality Environmental Impacts

There are no energy and non-air quality environmental impacts of compliance for adding diesel particulate filters.

5.2.4. Remaining Useful Life

The remaining useful lives of the Maalaea units do not impact the annualized capital costs of potential controls because the useful life of each Maalaea unit is assumed to be longer than the capital cost recovery period, which is twenty (20) years.

5.3. PARTICULATE MATTER CONCLUSION

The cost-effectiveness of adding diesel particulate filters is more than $41,200 per ton of PM_{10} for each diesel engine generator. These costs are similar to the BART analyses conducted for the first planning period. For the first planning period, the EPA concluded that PM_{10} controls were not cost effective.[23]

The results of the four-factor analysis are consistent with the conclusions, that PM_{10} controls are not required, reached for the first planning period. Therefore, Hawaiian Electric does not propose any PM_{10} emissions reduction measures in addition to the Hawaiʻi RPS, EEPS, and the GHG ERP to meet the RHR requirements.

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[23] Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaiʻi, U.S. EPA Region 9, May 14, 2012.

APPENDIX A : DETAILED COSTING

Appendix Table A-1. SCR Capital and Annual Cost Estimates - Diesel Engine Generators

			Table 5-6
Capital Recovery Factor (CRF)			0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2019	607.5	
	2005	468.2	
Capital Cost (2010 dollars)	($/Hp)		$98
Capital Cost (2019 dollars)	($/Hp)		$127
Annualized Capital Cost (2019 dollars)	($/Hp)		$12
Total Annual Cost Including Capital Recovery (2005 dollars)	($/Hp based on 1000 hrs/yr)		$40
Total Annual Cost Including Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$52
Total Annual Cost Minus Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$40
Annual Operating Cost (2019 Dollars)	**($/Hp/Hr)**		**$0.0399**

Source: *Assessment of Non-EGU* NO_X *Emission Controls, Cost of Controls, and Time for Compliance* , Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

			M5-M9 Estimate
M5 - M9 Nominal Design Output	(MW)		5.9
Capital Recovery Factor (CRF)			0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2019	607.5	
	2012	584.6	
Capital Cost (2012 dollars)	($)		$3,000,000
	($/MW)		$508,475
Capital Cost (2019 dollars)	($/MW)		$528,392.58
Annualized Capital Cost (2019 dollars)	**($/MW)**		**$49,877**

Source: *2012 Internal Engineering Study*

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]

CRF = 0.09

Where:

I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

Appendix Table A-2. SCR Capital and Total Annual Cost Estimate - Combustion Turbine Generators

			M14	M16	M17	M19
MW			20.0	20.0	20.0	20.0
Max Heat Input		(MMBtu/hr)	275	275	275	275
Capital Recovery Factor (CRF)			0.09	0.09	0.09	0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)						
2019		605.7				
1990		357.6				
Total Capital Investment (Eq. 1 - 1990 dollars)		($)	$1,672,762	$1,672,762	$1,672,762	$1,672,762
Capital Cost (2019 dollars)		($)	$2,833,311	$2,833,311	$2,833,311	$2,833,311
Annualized Capital Cost (2019 dollars)		($/yr)	$267,444	$267,444	$267,444	$267,444
Total Annual Cost (Eq. 2 - 1990 dollars)		($/yr)	$561,331	$561,331	$561,331	$561,331
Total Annual Cost (2019 dollars)		($/yr)	$950,777	$950,777	$950,777	$950,777
Maui Construction Cost Multiplier [A]			1.938	1.938	1.938	1.938
Total Annual Cost (2019 Dollars)		**($/yr)**	**$1,842,606**	**$1,842,606**	**$1,842,606**	**$1,842,606**

Total capital investment (1990 dollars) = 4744 x (MMBtu/hr) + 368162 Equation 1

Total Annual Cost (1990 dollars) = 1522.5 x (MMBtu/hr) + 142643 Equation 2

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.09

Where:

I = Interest Rate (7% interest)

a = Equipment life (20 yrs)

Source: *Assessment of Non-EGU NO_X Emission Controls, Cost of Controls, and Time for Compliance*, Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

[A] The Maui construction cost multiplier is based on cost of construction geographical multipliers from the *RSMeans Mechanical Cost Data 2016 to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.*

APPENDIX B : HAWAIIAN ELECTRIC REGIONAL HAZE VISIBILITY CONSIDERATIONS

Appendix B:
Hawaiian Electric Regional Haze Visibility Considerations

Fifth Factor Considerations for SO_2 ,NOx, and PM Controls

AECOM Project Number: 60626547

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September 14, 2020

Hawaiian Electric[1] Regional Haze Visibility Considerations

Fifth Factor Considerations for SO_2, NOx and PM Controls

1. Executive Summary

The EPA has issued multiple guidance documents to assist states and facilities address the requirements of the Regional Haze Rule (“RHR”). This guidance allows states to consider, as part of their review of the Four Factor evaluation of possible emission controls for the Second Decadal Review, a “5th factor” which involves consideration of visibility impacts of candidate control options. This appendix introduces several Hawaiʻi-specific issues that impact the visibility impact of potential sulfur dioxide (“SO_2”), nitrogen oxides (“NOx”) and particulate (“PM”) control options for Hawaiian Electric sources relative to the two Class 1 areas in Hawaiʻi: the Haleakalā National Park on the island of Maui and the Hawaiʻi Volcanoes National Park on Hawaiʻi Island. The issues discussed in this report are summarized below:

1) Due to unique atmospheric chemistry, NOx emissions tend to remain in the gaseous (and invisible) phase in warm weather, and only form visible NO_3 (“nitrate”) particulate aerosol in cold weather. This is verified by monitoring data in the Interagency Monitoring of Protected Visual Environments (“IMPROVE”) network in the two national parks mentioned above.

2) The persistent East North East (“ENE”) trade winds experienced by the state of Hawaiʻi places emission sources on several islands (or portions of islands such as Maui) downwind of the national parks, limiting the likelihood that any emissions from these sources would even reach the parks. Modeling conducted with the California Puff Model (“CALPUFF”) for the First Decadal Review confirms the minimal potential for haze impact of the subject Hawaiian Electric sources on the islands of Oʻahu and Maui due to the predominance of the trade winds. The EPA’s Federal Implementation Plan (“FIP”) issued in 2012 agreed with this assessment.

3) EPA previously determined that in Hawai´i haze due to direct PM was a very small component of haze and that further controls would not be effective in improving visibility. The observed haze speciation is reviewed in this report to confirm this determination.

4) The State of Hawaiʻi Department of Health Clean Air Branch (“DOH”) should request that the EPA (consistent with their first decadal review approach) set aside NOx and PM from the list of haze precursors for Hawaiʻi due to the unique NOx haze chemistry and climate, leaving SO_2 as

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[1] “Hawaiian Electric” or the “Company” refers to Hawaiian Electric Company, Inc. (or “HE”), Hawaiʻi Electric Light Company, Inc. (or “HL”) and/or Maui Electric Company, Limited (or “ME”). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

the primary precursor pollutant for haze. Hawaiian Electric requests that the DOH make this proposal to the EPA.

5) In the recent past, volcanic activity on Hawaiʻi Island has produced as much as 2 million tons of SO_2 emissions per year[2,3] (emissions vary yearly and have decreased significantly since September 2018). Additionally, the volcanic activity, although the volcano eruption ended in September 2018, has contributed significant NOx emissions in the past[4]. These historic volcanic SO_2 emissions are about three orders of magnitude (approximately 1,000 times) greater than anthropogenic SO_2 emissions. Although the IMPROVE monitors indicate that sulfate haze is the most important haze species, it is evident from monthly haze trends and the likelihood of winds from the volcanic activity reaching the IMPROVE monitors that the overwhelming historic sulfate haze influence comes from natural sources (i.e., volcanic activity).

The locations of the affected Hawaiian Electric sources and the two national parks are shown in Figure B-1. The remainder of this appendix presents details of the above issues and recommendations for how this information should be considered in selection of facilities for Four-Factor analyses and for evaluating potential pollutant control options.

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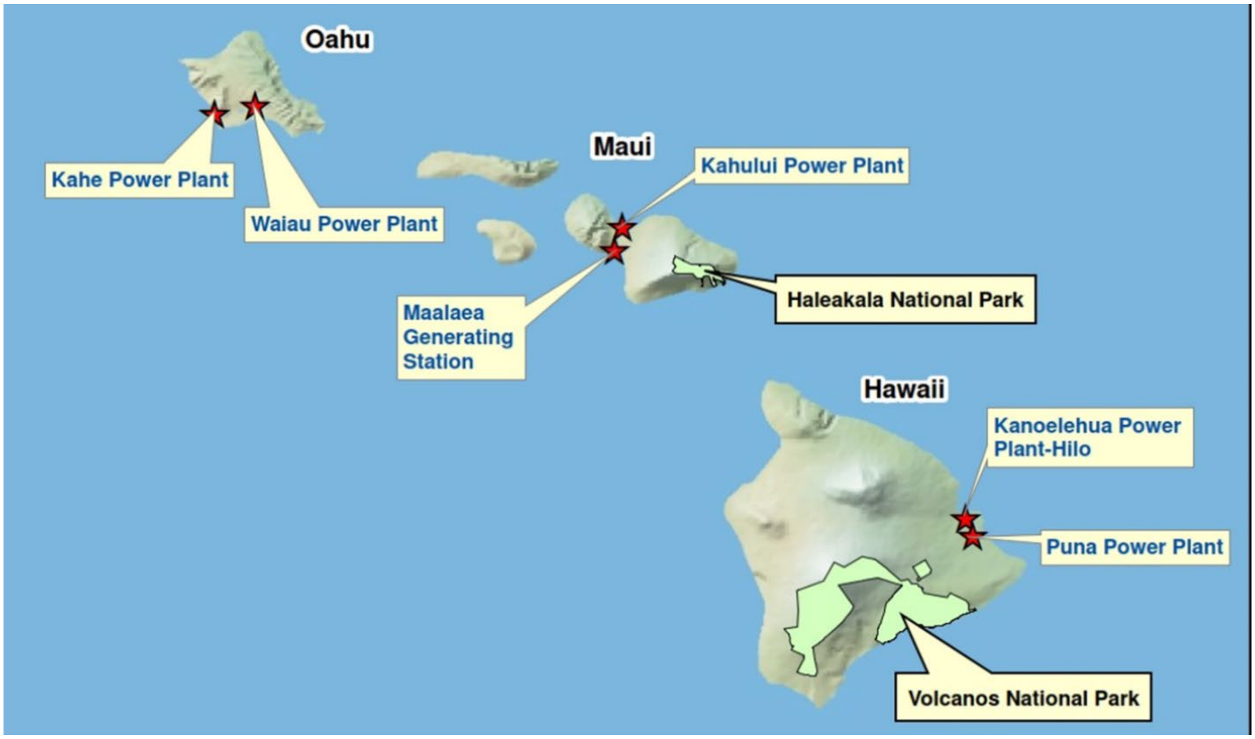
[2] Information on the volcanic SO_2 emissions in 2014 was provided by the EPA in their SO_2 National Ambient Air Quality Technical Support Document at EPA's 2016 SO_2 NAAQS TSD, at https://www.epa.gov/sites/production/files/2016-03/documents/hi-epa-tsd-r2.pdf.

[3] Information on 2014-2017 volcanic SO_2 emissions is available in this journal article: Elias T, Kern C, Horton KA, Sutton AJ and Garbeil H. (2018) Measuring SO_2 Emission Rates at Kīlauea Volcano, Hawaii, Using an Array of Upward-Looking UV Spectrometers, 2014–2017. *Front. Earth Sci.* 6:214. doi: 10.3389/feart.2018.00214. https://www.frontiersin.org/articles/10.3389/feart.2018.00214/full.

[4] The NOx emissions from Hawaiʻi Island volcanic activity is unknown, but could have historically been as high as 25,000 tons per year if the NOx emissions rate equals 6% of SO_2 emissions rate. The 6% is derived from worldwide volcanic NOx emissions estimate of 1.0 Teragram ("Tg" – trillion grams)/year ("yr") nitric oxide ("NO") (or 1.5 Tg/yr NO2) from https://www.chemistryworld.com/features/a-volcanic-breath-of-life/3004482.article and worldwide volcanic SO2 estimate of 23 Tg/yr from https://www.nature.com/articles/srep44095.

Figure B-1:
Location of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas



2. EPA Guidance Regarding Considerations of Visibility Impacts

The EPA issued "Guidance on Regional Haze State Implementation Plans for the Second Implementation Period"[5] in August 2019. This guidance allows states to consider, as part of its consideration of emission controls to include for the Second Decadal Review a "5th factor" which involves consideration of visibility impacts of candidate control options. A companion document[6] issued in September 2019 that involves the EPA's visibility modeling results for 2028 is entitled, "Availability of Modeling Data and Associated Technical Support Document for the EPA's Updated 2028 Visibility Air Quality Modeling".

On Page 11 of the August 2019 guidance, the EPA states:

> *"When selecting sources for analysis of control measures, a state may focus on the PM species that dominate visibility impairment at the Class I areas affected by emissions from the state and then select only sources with emissions of those dominant pollutants and their precursors."* . . .

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[5] Available at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.
[6] Available at https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-Transmittal_Memo.pdf.

> *"Also, it may be reasonable for a state to not consider measures for control of the remaining pollutants from sources that have been selected on the basis of their emissions of the dominant pollutants"*

Further, on Page 36 and 37, the EPA states:

> *"Because the goal of the regional haze program is to improve visibility, it is reasonable for a state to consider whether and by how much an emission control measure would help achieve that goal." . . .*
>
> *". . . EPA interprets the CAA and the Regional Haze Rule to allow a state reasonable discretion to consider the anticipated visibility benefits of an emission control measure along with the other factors when determining whether a measure is necessary to make reasonable progress."*

Consequently, the extremely low likelihood for impact to Class I visibility impairment from control of certain facility pollutants and the plant locations relative to the Class I areas is appropriate for consideration when evaluating the need for further control of these emissions for Regional Haze Reasonable Progress.

3. Nitrate Haze Composition Analysis

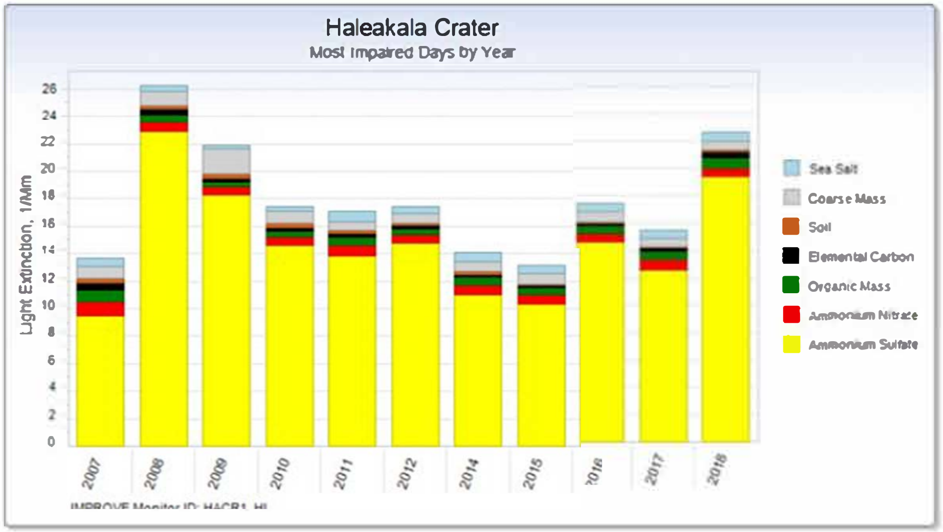
Nitrate haze composition analyses for the Haleakalā and Hawaiʻi Volcanoes National Parks are available at the IMPROVE web site at http://vista.cira.colostate.edu/Improve/pm-and-haze-composition/. Figure B-2 provides various charts for the haze species composition at the Haleakalā Crater IMPROVE site, and Figure B-3 provides a time series of stacked bars by species for a recent year at that site. Figures B-4 and B-5 provide similar information for the Hawaiʻi Volcanoes IMPROVE site. Note that these figures show information for the worst 20 percent ("%") impaired days, which is the focus of the RHR for reducing haze. The goal for each decadal review is to track the progress of haze reduction for the worst 20% impaired days; reviewing the composition of haze on these days is a key element in understanding what precursor pollutants to control to achieve the goal.

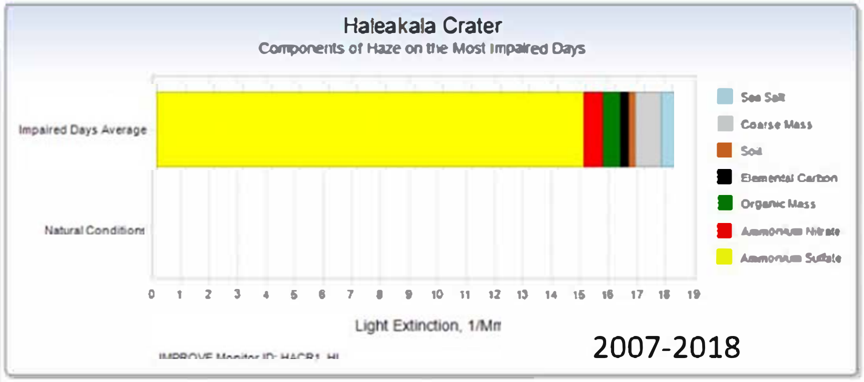
The data for both National Parks shows that the contribution of nitrates to haze is very low as a percentage of the total, but it is also low as an absolute value for extinction (visibility impairment). The total nitrate haze impairment is approximately 1 inverse megameter ("Mm^{-1}"), equivalent to approximately 0.25 deciview ("dv"), or less. This is the impairment at these monitors due to ALL sources, natural and anthropogenic.

The minimal impact of nitrate haze is clearly illustrated in the Hawaiʻi National Park monitoring data and is much smaller than found at many monitors in other Class 1 areas around the country. This is in large part due to the unique chemistry of nitrate haze, as discussed below.

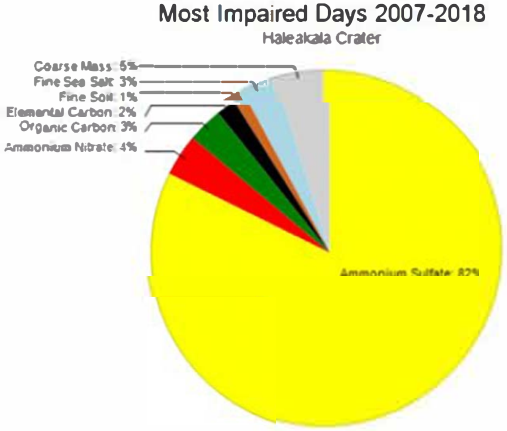
Figure B-2: Charts Showing the Worst 20% Haze Days Multiple-Year Species Composition for the Haleakalā Crater IMPROVE Site

Light Extinction Summary - Most Impaired Days





2007-2018



Haleakala Crater IMPROVE monitor

Data source for Figures B-2 through B-5: http://views.cira.colostate.edu/fed/SiteBrowser/Default.aspx?appkey=SBCF_VisSum.

Figure B-3: Time Series of 2018 Daily Haze Extinction Composition Plots for the Haleakalā Crater IMPROVE Site

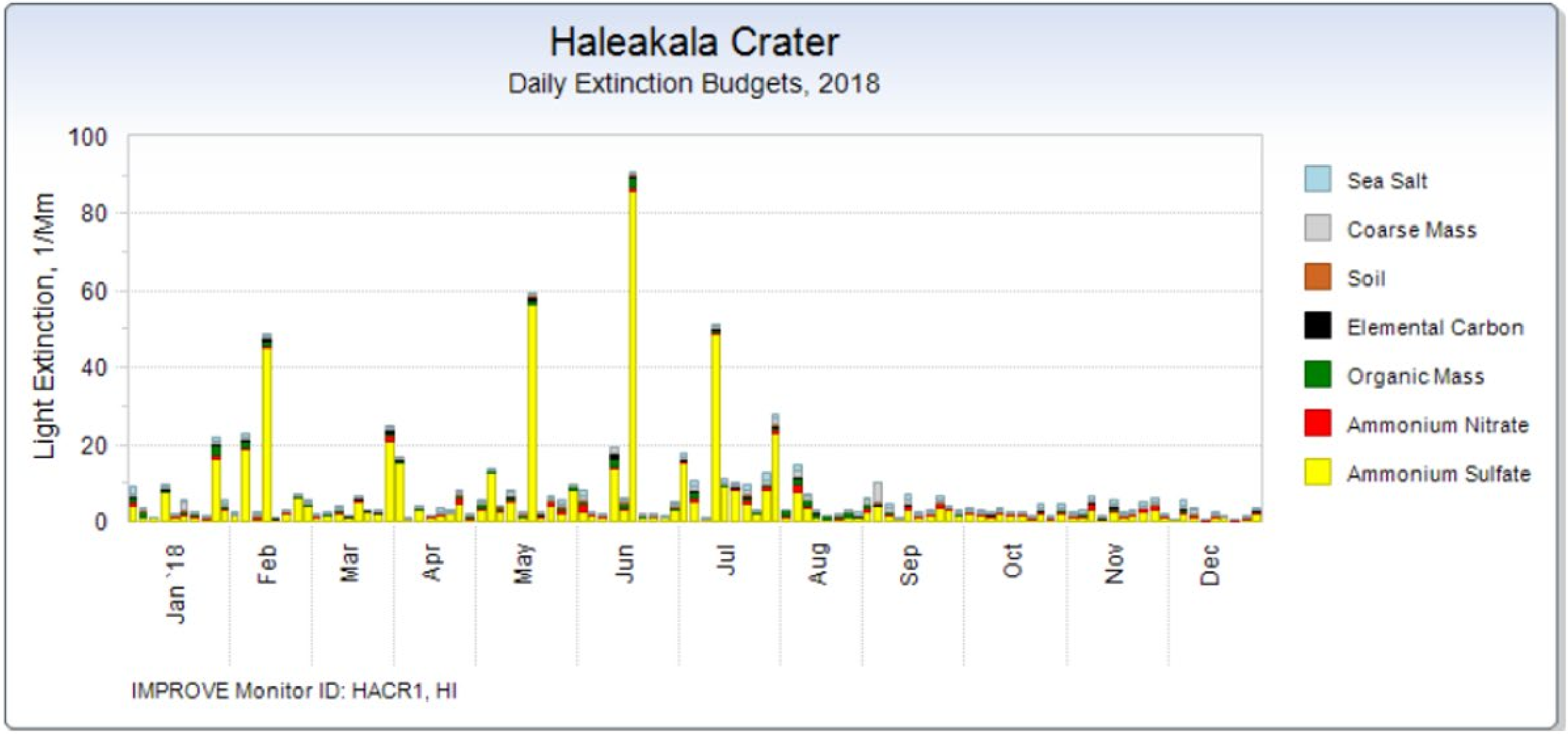
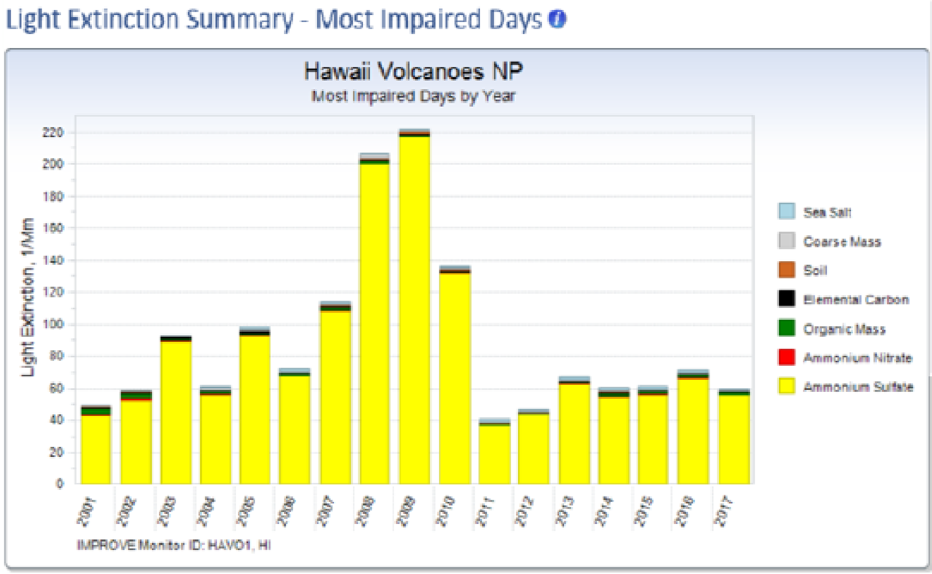
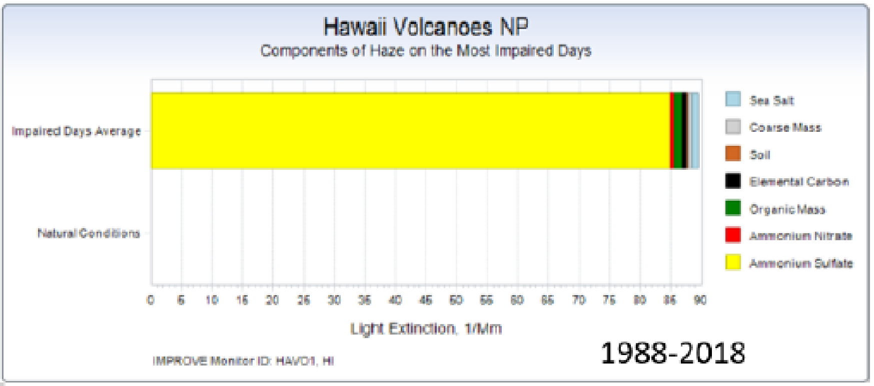
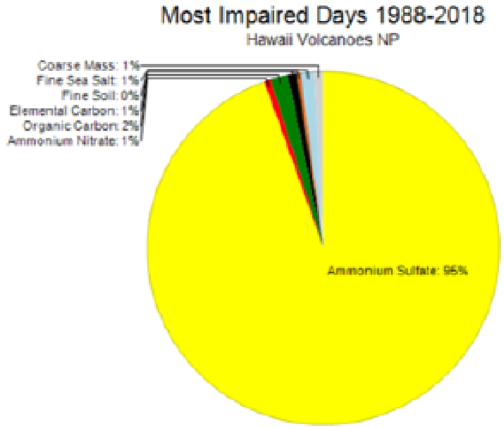


Figure B-4: Charts Showing the Worst 20% Haze Days Multiple-Year Species Composition for the Hawai'i Volcanoes IMPROVE Site



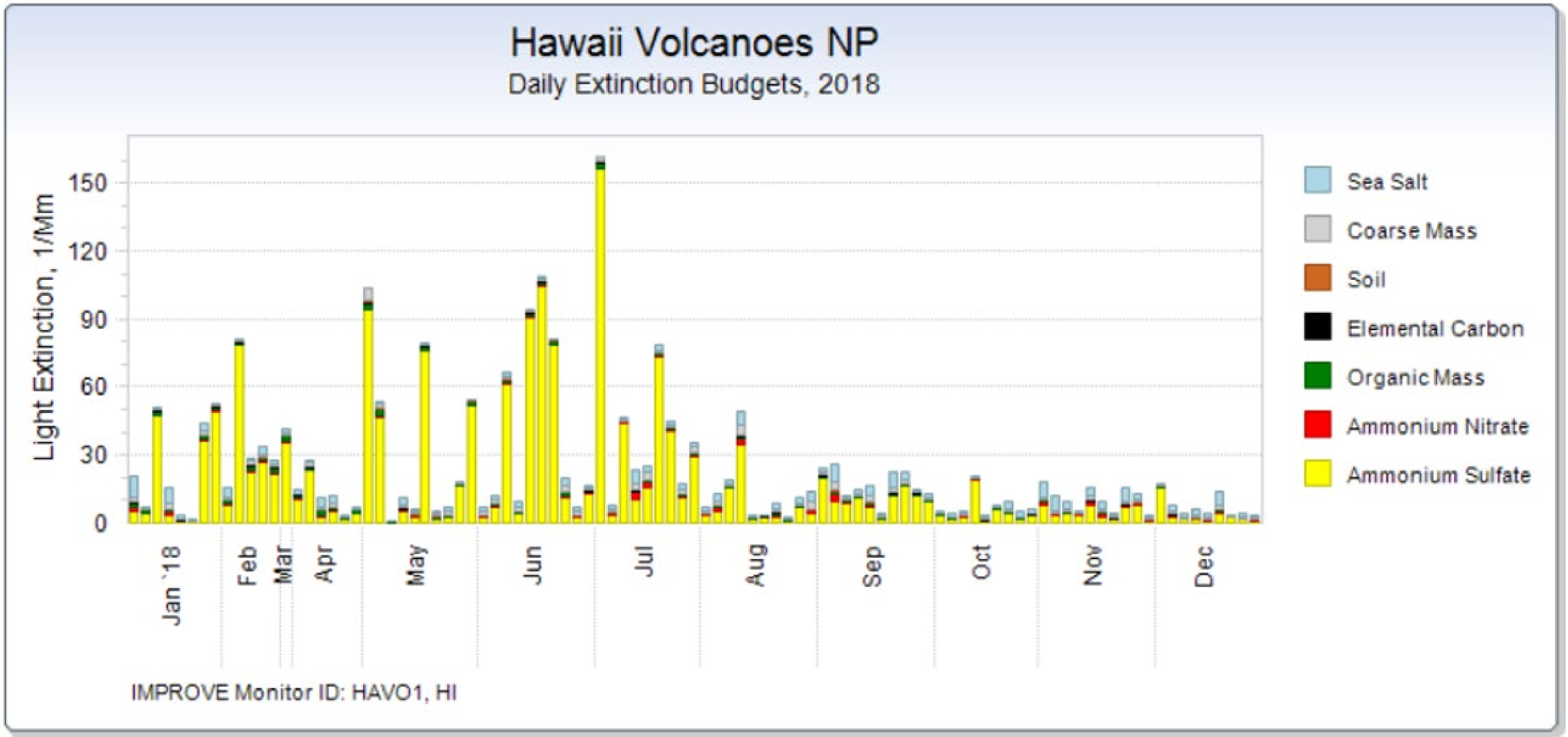


1988-2018



Hawaii Volcanoes NP IMPROVE monitor

Figure B-5: Time Series of 2018 Daily Haze Extinction Composition Plots for the Hawai'i Volcanoes IMPROVE Site



The nitrate contribution to visibility impairment in the above bar charts is shown as a narrow "red" segment. The small size relative to other constituents clearly shows that nitrate is only a small contributor. Additionally, the Figures B-6 and B-7 below which presents only the ammonium nitrate visibility impairment also shows that nitrates, already small contribution, is trending downward.

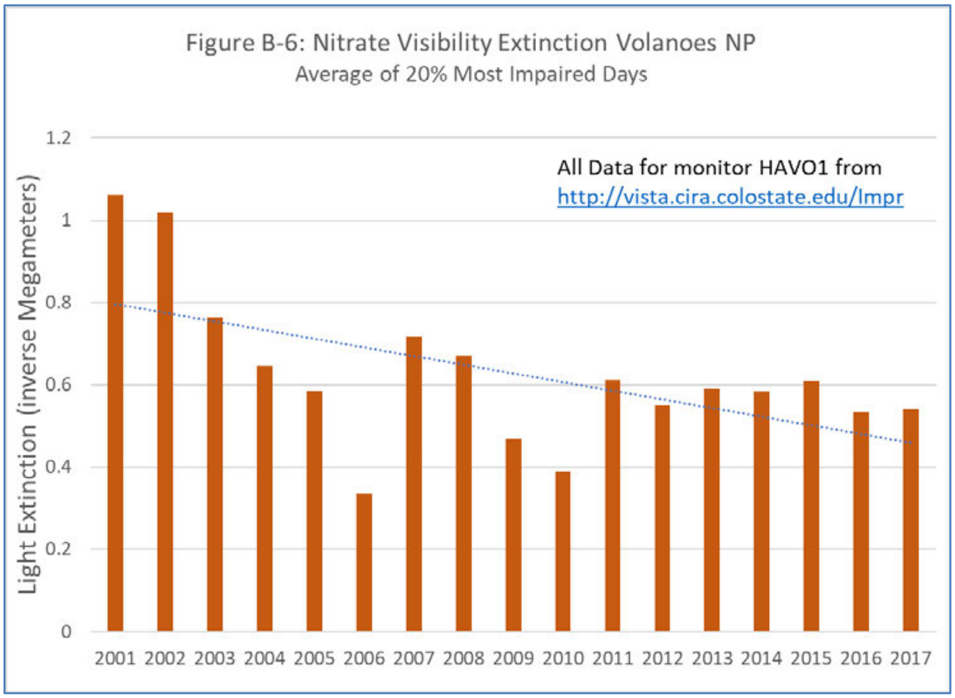


Figure B-6: Nitrate Visibility Extinction Volanoes NP

Average of 20% Most Impaired Days

All Data for monitor HAVO1 from http://vista.cira.colostate.edu/Impr

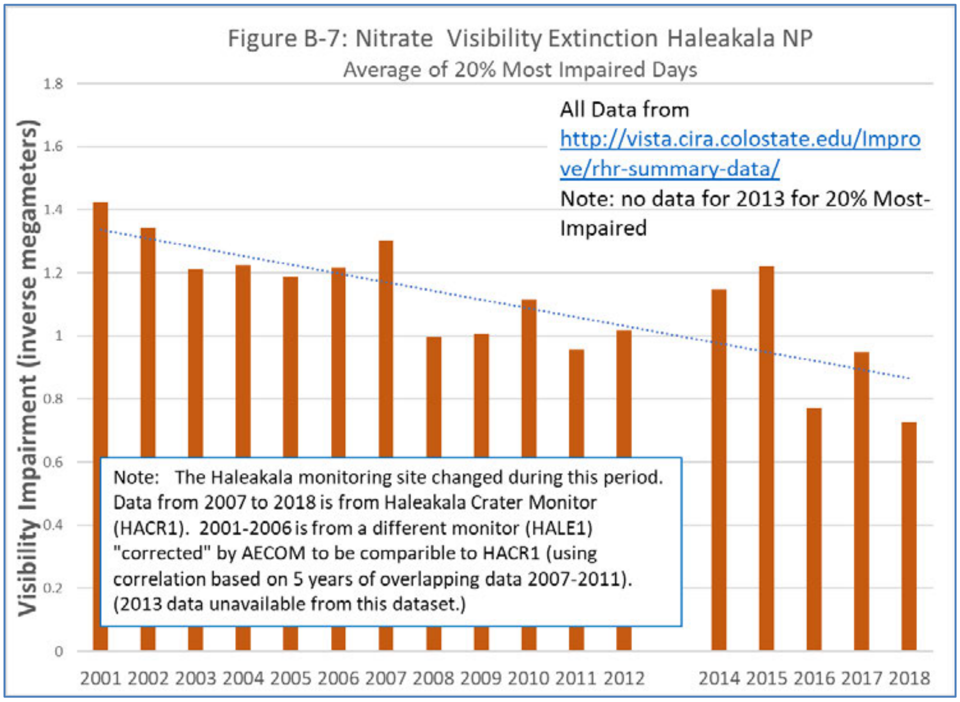


Figure B-7: Nitrate Visibility Extinction Haleakala NP

Average of 20% Most Impaired Days

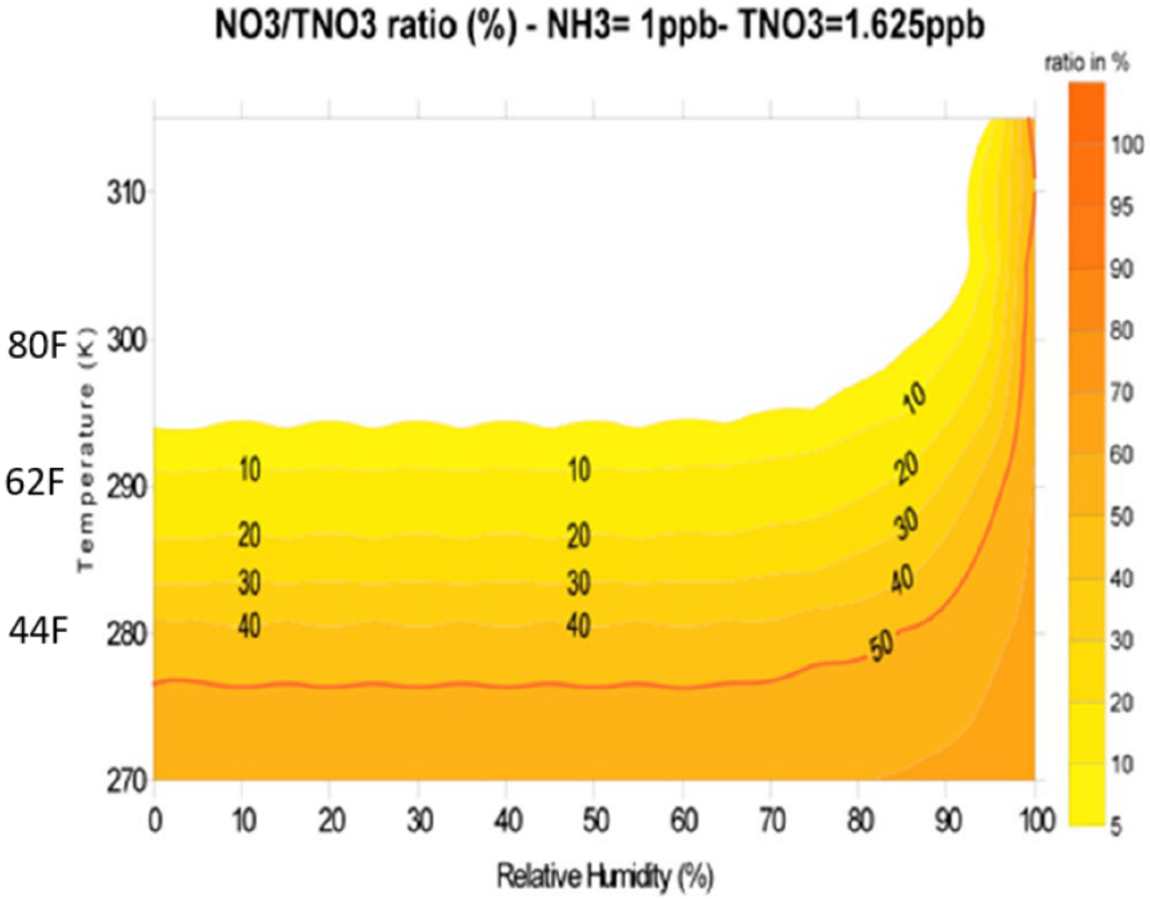
All Data from http://vista.cira.colostate.edu/Improve/rhr-summary-data/

Note: no data for 2013 for 20% Most-Impaired

Note: The Haleakala monitoring site changed during this period. Data from 2007 to 2018 is from Haleakala Crater Monitor (HACR1). 2001-2006 is from a different monitor (HALE1) "corrected" by AECOM to be comparible to HACR1 (using correlation based on 5 years of overlapping data 2007-2011). (2013 data unavailable from this dataset.)

The chemistry of nitrate haze formation is highly dependent upon ambient temperature, and to a lesser extent upon humidity. As discussed in the CALPUFF model formulation[7] and in CALPUFF courses, total nitrate in the atmosphere ($TNO_3 = HNO_3 + NO_3$) is partitioned into gaseous nitric acid ("HNO_3") (invisible, and not haze-producing) and nitrate ("NO_3") haze particles according to the equilibrium relationship between the two species, which is affected by temperature and humidity.

Figure B-8: CALPUFF Example Plot of Aerosol Percentage of Total NOx Equilibrium



The potential for the formation of haze due to NOx emissions is very low in Hawai'i because of the warm weather conditions year-round. This strong dependency of the equilibrium relationship between invisible gaseous HNO_3 and visible NO_3 haze particles as a function of ambient temperature is illustrated in Figure B-8. In Figure B-8, it is evident that for most conditions, the percentage of total nitrate in the form of particulate (NO_3) is less than 20% for temperatures above approximately 286 degrees Kelvin (approximately 55 degrees Fahrenheit). Temperatures at most locations in Hawai'i rarely get that low and are not that low at any of the Hawaiian Electric plant locations.

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[7] Documentation for the CALPUFF modeling system is available from links provided at https://www.epa.gov/scram/air-quality-dispersion-modeling-alternative-models#calpuff.

This dependency of nitrate haze formation as a function of temperature (and season) for more seasonally-varying locations in the United States is shown in the September 2019 EPA modeling report[2] in Figure B-9 (from Appendix A of that report). This figure shows that the thermodynamics of the nitrate haze equilibrium result in much greater particulate formation in winter versus other seasons for more temperate climates, while NOx emissions are expected to be relatively constant over the entire year. This implies that NOx emission reductions would only be effective for haze reduction during cold winter months, while consideration of NOx emission reductions in other months is relatively ineffective.

It should also be noted that volcanic activity on Hawaiʻi Island may also be a large source of NOx in the state. Volcanoes are commonly thought of as large sources of SO_2, but they also can emit significant amounts of NOx. Laboratory analysis[8] of NOx emissions content in volcanic exhaust indicates a substantial component, likely caused by thermal contact of air with lava. The annual worldwide volcano NOx emissions (as NO_2) is estimated[3] at approximately 1.5 teragrams ("Tg" – trillion grams).

In summary, nitrate haze is a very small component in Hawaiʻi's Class I areas, which is expected given nitrate chemistry and is verified by the IMPROVE monitoring data. The mulitple-year average of the nitrate haze impact for worst 20% days at the two areas is approximately Mm-1, or less than 0.5 delta-dv. This total nitrate haze impact is less than the de minimis contribution threshold used to eliminate a single source from consideration for controls during the First Decadal Review period.

Due to the low haze impact of NOx (even if every source in the state and the volcano was eliminated), the state of Hawaiʻi should limit the haze precursors control evaluations to SO_2 for the Second Decadal Review. A similar conclusion was reached during the First Decadal Review, for which the EPA did not consider NOx controls to be material. The State of Hawaiʻi Department of Health should work with the EPA to provide this technical justification to remove NOx as a haze precursor for the state of Hawaiʻi.

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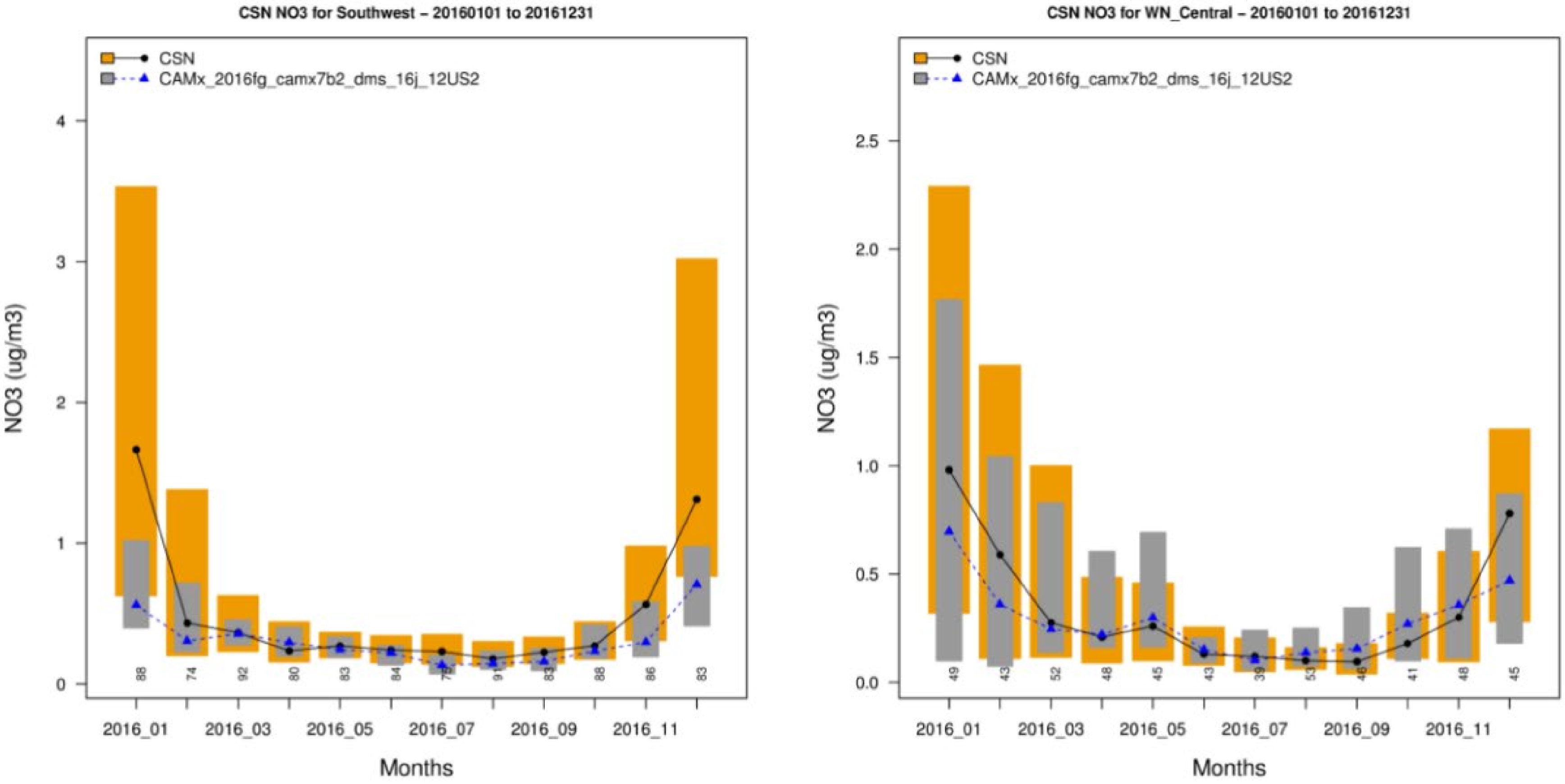
[8] Mather, T., 2004. A Volcanic Breath of Life? Chemistry World, 30 November 2004 Featured Article. https://www.chemistryworld.com/features/a-volcanic-breath-of-life/3004482.article.

Figure B-9: Monthly Variation of Nitrate Particulate Concentrations for Selected IMPROVE Sites from EPA 2019 Modeling Report



4. PM Species Haze Composition Analysis

In their Federal Implementation Plan Technical Support Document[9], EPA noted that "due to the overwhelming contribution of sulfate to visibility impairment at the nearby Hawaii Volcanoes Class I area, it is unlikely that reductions in these pollutants [NOx and PM]…would have a measurable impact on visibility at that area."

It is clear from a review of the haze speciation shown in Figures B-2 through B-5 that the contribution to haze of direct particulate species such as elemental carbon, soil, and coarse mass is relatively low. Furthermore, emissions of coarse PM mass (ash) from the volcanic activity can be very high (clearly evident from photos of volcanic activity) to the extent that it may result in aviation alerts. These emissions can be much greater than emissions from power plants and can constitute a significant portion of the direct PM-caused haze shown in Figures B-2 through B-5. The remaining human-caused haze due to direct PM emissions is therefore a very small component of the total haze, and this determination is consistent with EPA's 2012 assessment.

5. Predominant Trade Winds in Hawaiʻi

The EPA's FIP for Hawaiʻi for the First Decadal Review (77 FR 61478, October 9, 2012) acknowledged the direction of the predominant trade winds in Hawaiʻi and thus did not require controls on upwind sources (i.e., sources on Oʻahu and Maui). Figure B-10 shows the locations of the Hawaiian Electric sources and the national parks, along with wind rose plots for airports on Maui and Oʻahu. The wind rose plots show that the wind is almost always from the northeast and rarely blows from the Hawaiian Electric facilities on Oʻahu or Maui toward either of Hawaiʻi's Class 1 areas.

The EPA CALPUFF modeling conducted for the First Decadal Review confirms the expected low impacts from sources on Maui, even though the sources were relatively close to Haleakalā National Park. This result is due to the fact, as stated above, that winds rarely blow the emissions from sources downwind from the parks back to the parks, and the CALPUFF modeling confirmed the low impact from occasional periods when the wind may blow toward the parks from the sources modeled. The Western Regional Air Partnership ("WRAP") Q/d analysis that included several sources on the islands of Oʻahu and Maui in the four-factor analysis did not consider the wind patterns. A review of past modeling and the EPA's 2012 FIP should lead to a dismissal of those sources from inclusion in four-factor analyses for the second decadal review period.

The geometry and wind roses shown in Figure B-10 and previous CALPUFF modeling both indicate that Hawaiian Electric generating stations on Oʻahu and Maui would have minimal impact to Class 1 area haze. Because of this, and the minimal impact of NOx due to nitrate chemistry, consideration of

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[9] EPA, May 14, 2012. Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii. EPA docket EPA-R09-OAR-2012-0345-0002 via www.regulations.gov.

potential additional pollution controls at Hawaiian Electric facilities for Regional Haze progress should be limited to SO_2 for sources on Hawaiʻi Island.

6. Natural Sources of SO_2 From Volcanic Activity

Volcanic activity on the Hawaiʻi Island represents a unique and challenging complication to understanding haze in Hawaiʻi Class I areas. The Kilauea volcano on Hawaiʻi Island has been active for several years, and the levels of SO_2 emissions are being monitored by the United States Geological Survey. As shown in Figure B-11[10] (related to the SO_2 National Ambient Air Quality Standards implementation and monitoring), there were over 2 million tons of SO_2 emissions from volcanic activity on Hawaiʻi Island in the year 2014, compared to roughly 2,000 tons of power plant SO_2 emissions for that year. As noted in a *Frontiers in Earth Science* 2018 article[11], the volcanic SO_2 emissions have been relatively steady at levels close to 2 million TPY for the period of 2014 to 2017. The volcanic SO_2 emissions have decreased after the Kilauea eruption ended in September 2018, but remain significant. The USGS preliminary estimates of annual volcanic emissions of SO_2 for 2019 are 17,119 tons/year[12].

The extremely high and variable levels of natural SO_2 emissions present a significant challenge for defining "impaired" haze days because the same pollutant (i.e., SO_2) is emitted by volcanic activity and the power plants and other combustion sources. Therefore, the RHR glidepath for the two Class I areas in Hawaiʻi is difficult to establish if naturally-caused haze is to be excluded from the analysis.

There appears to be very little anthropogenic haze impairment remaining at Haleakalā National Park because there are very few sources on Maui upwind of the park and there are no land masses upwind of Maui for thousands of kilometers. For Hawaiʻi Island, the largest sources of SO_2 are natural sources that are part of (or adjacent to) the park.

Even the anthropogenic sources (from power plants) are projected to be phased out well before the end point of the RHR (i.e., 2064) by Hawaiʻi's State Renewable Portfolio Standards Law ("RPS") implementing requirements to convert 100% of the state's electrical generation to renewable energy sources. This RPS law (Hawaiʻi Revised Statute §269-92) will substantially reduce emissions of haze precursors by 2045. Further details of the past and future benefits of the RPS requirements are detailed in separate Appendix C.

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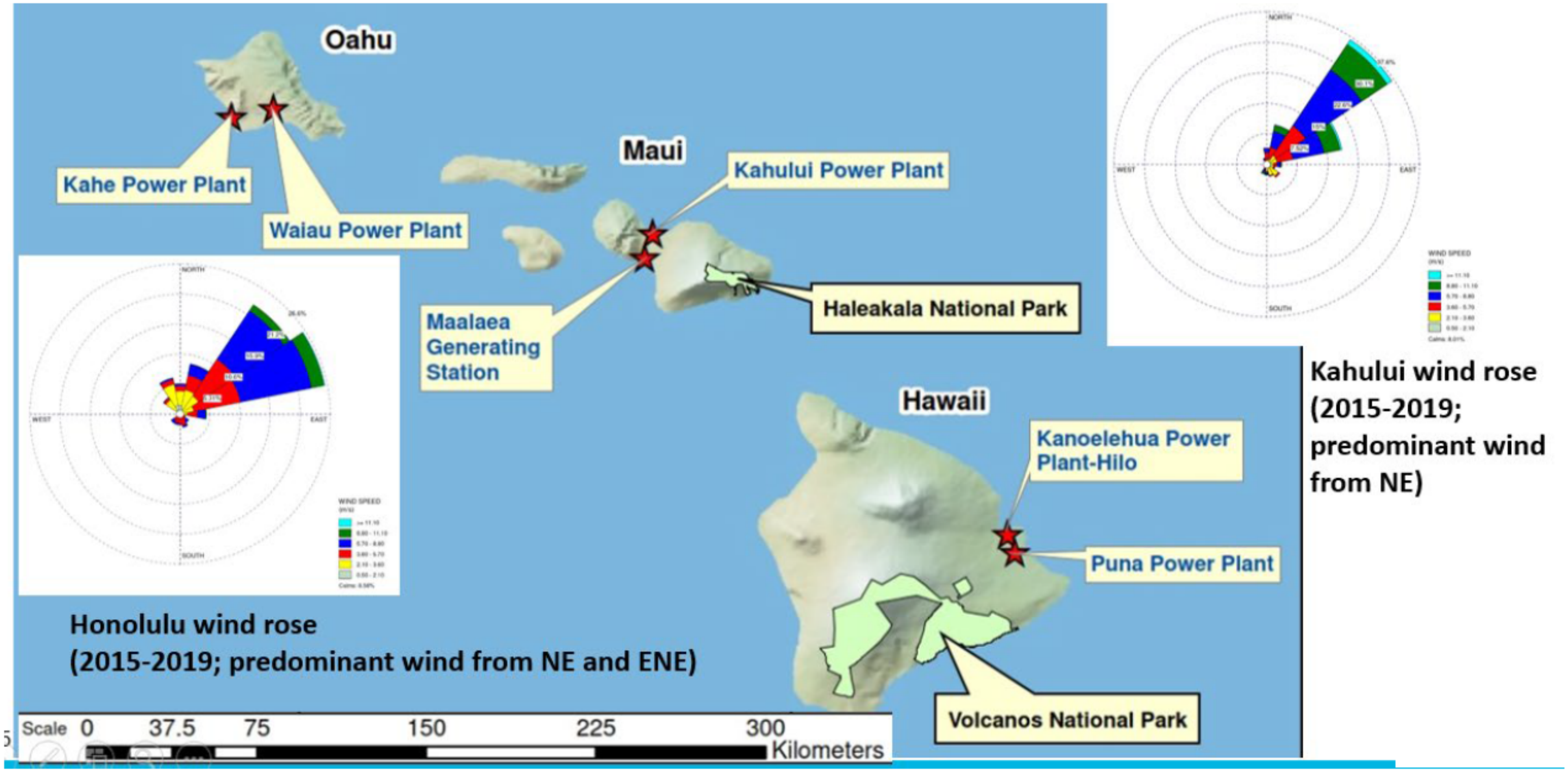
[10] https://www.epa.gov/sites/production/files/2016-03/documents/hi-epa-tsd-r2.pdf.

[11] Elias, T., C. Kern, K. Horton, A. Sutton, and H. Garbeil, 2018. Measuring SO_2 Emission Rates at Kīlauea Volcano, Hawaiʻi, Using an Array of Upward-Looking UV Spectrometers, 2014–2017. *Front. Earth Sci*. 6:214. doi: 10.3389/feart.2018.00214. https://www.frontiersin.org/articles/10.3389/feart.2018.00214/full.

[12] Hawaii Dept. of Health comment letter to Hawaiian Electric Light Company regarding Puna Generating Station Four Factor Analysis; July 8, 2020.

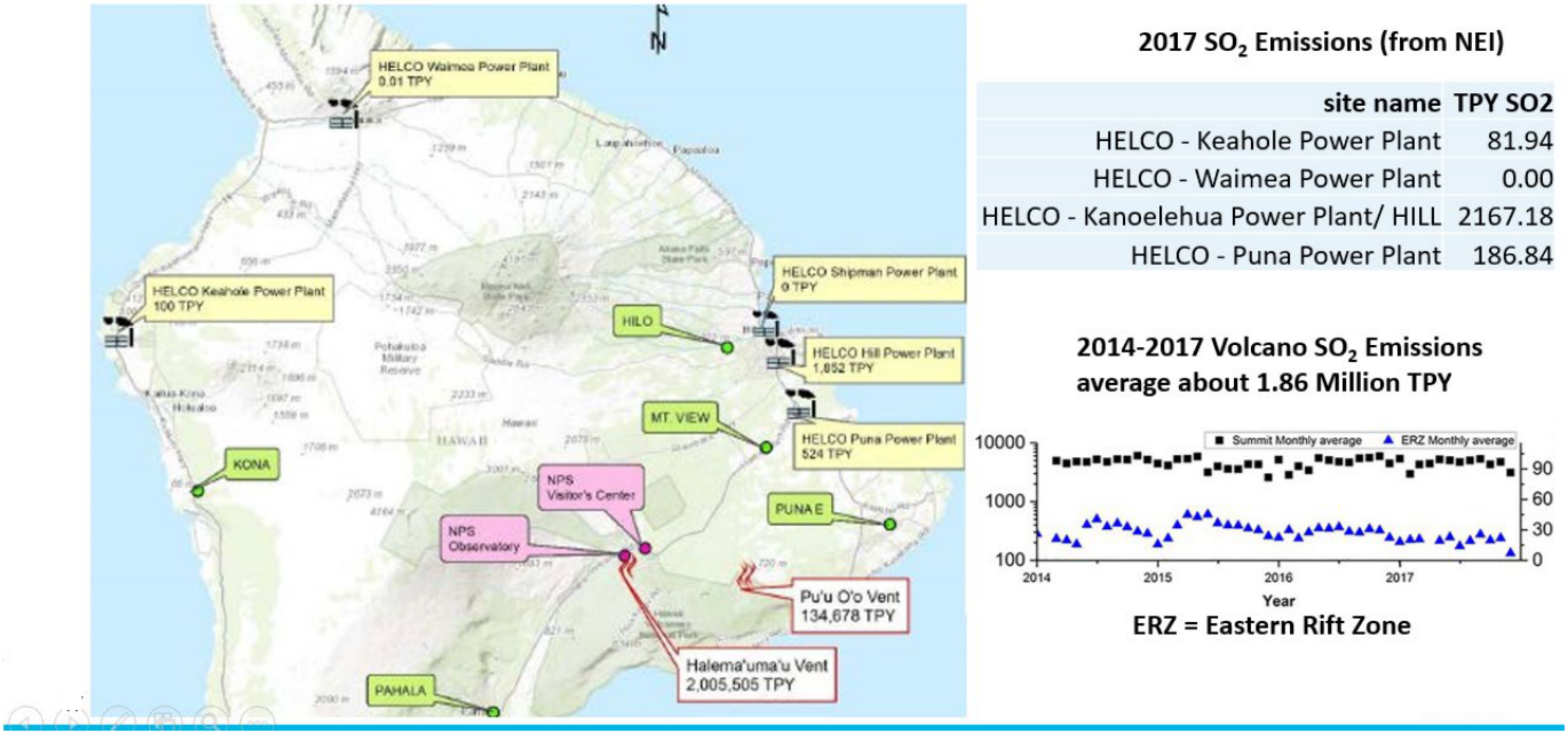
Figure B-10: Geography of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas, with Wind Roses



Honolulu wind rose
(2015-2019; predominant wind from NE and ENE)

Kahului wind rose
(2015-2019;
predominant wind
from NE)

Figure B-11: Geography of Hawaiian Electric Sources Asked to Conduct Four-Factor Analyses and PSD Class I Areas, with Wind Roses



2017 SO_2 Emissions (from NEI)

site name	TPY SO2
HELCO - Keahole Power Plant	81.94
HELCO - Waimea Power Plant	0.00
HELCO - Kanoelehua Power Plant/ HILL	2167.18
HELCO - Puna Power Plant	186.84

2014-2017 Volcano SO_2 Emissions average about 1.86 Million TPY

ERZ = Eastern Rift Zone

7. Conclusions

The state of Hawaiʻi is isolated from all other states and has very unique regional haze issues due, in part, to its tropical climate, the prevalent trade winds, very large natural emissions of haze precursors, and statewide commitment to renewable energy.

- Emission sources on Oʻahu and Maui are downwind of Hawaiʻi's Class 1 areas and do not contribute to haze issues, such that additional emission controls would not contribute to further reasonable progress at either of Hawaiʻi's Class 1 area National Parks. This is consistent with the EPA's First Decadal Review findings.

- Additionally, NOx emissions do not significantly contribute to haze in Hawaiʻi due the nitrate chemistry and Hawaiʻi's warm climate, and additional NOx controls would likewise not contribute to further reasonable progress. Therefore, NOx should not be regulated as a contributing precursor to haze in Hawaiʻi; especially from Oʻahu and Maui sources that are downwind of the parks. If they are reviewed as precursors, consideration should be given to their insignificant contribution when evaluating possible controls.

- Direct PM emissions constitute a very small portion of the haze associated with the worst 20% haze days in the Hawaiʻi Class 1 areas. Furthermore, significant portions of the observed haze in the categories of elemental carbon, soil, and coarse mass are due to volcanic emissions. Therefore, further PM controls on power plant sources would not have a significant benefit for visibility at these Class 1 areas.

- For the above reasons, the only pollutant that should be considered for possible haze controls in the state of Hawaiʻi is SO_2 which is consistent with the findings of the First Decadal Review. Furthermore, the only Hawaiian Electric sources to be considered for a four factor analysis for SO_2 should be those that are predominantly upwind of a Class I area which include only the Puna and Kanoelehua-Hill Generating Stations on Hawaiʻi Island.

- Hawaiʻi's Class I area haze impacts are principally due to natural sources. Volcanic emissions of precursor SO_2 during the 2014-2017 period of analysis were three orders of magnitude greater than the anthropogenic emissions on Hawaiʻi Island. Since these natural emissions are the principal cause of haze at the two Class 1 areas in the state and are difficult to distinguish from the relatively small amount of anthropogenically-caused haze, photochemical grid modeling is not practical or even needed. The definition of "impaired days" for Hawaiʻi Volcanoes National Park as referenced in some of the figures in this report is uncertain due to the overwhelming influence of natural emissions of SO_2.

- For Haleakalā National Park, with the lack of upwind anthropogenic sources, it could be reasonably concluded that natural conditions are already attained, and no further Reasonable Progress modeling (or controls) is needed. For Hawaiʻi Volcanoes National Park, the only United

States anthropogenic potential sources are those upwind of the park on Hawaiʻi Island; all other sources in the state are not contributing to haze at the Class 1 areas.

- Implementation of Hawaiʻi's RPS (discussed in detail in Appendix C) will provide a dramatic reduction of virtually all power plant haze-causing emissions in the state of Hawaiʻi well before the year 2064. This Hawaiʻi state law established enforceable requirements that a certain percentage of electricity must be generated from renewable energy sources by the end of identified benchmark years leading to 100percent renewable energy by 2045. The interim targets are 30 percent by 2020, 40 percent by 2030, and 70 percent by 2040 which provide an RPS "glide path" for EGUs that mirrors the RHR visibility improvement glide path for the next few decades. No separate new regional haze measures for EGUs are needed to assure reasonable progress for this decadal period.

Plans for renewable energy sources, the likely reduction in utilization of fossil-fueled electric generation in this interim period, the unique climate and wind patterns, and the difficulty of addressing the high volcanic emissions should be considered in the current planning for the Second Decadal Review process for the state of Hawaiʻi.

APPENDIX C : HAWAI‘I’S RENEWABLE PORTFOLIO STANDARDS CONTRIBUTION TO REGIONAL HAZE PROGRESS

Appendix C:
Hawai‘i’s Renewable Portfolio Standards (“RPS”) Contribution to Regional Haze Progress

AECOM Project Number: 60626547

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March 30, 020

Hawaiʻi's Renewable Portfolio Standards ("RPS") Contribution to Regional Haze Progress

1. Executive Summary

Hawaiʻi's ongoing conversion of fossil-fueled electric generation to renewable energy sources as mandated by the Hawaiʻi Revised Statute ("HRS") §269-92 Renewable Portfolio Standards ("RPS") is significantly decreasing emissions from Hawaiʻi's electric generating stations. Past actual and expected future decreases in usage of fossil-fueled electric generating units ("EGUs") are achieving emissions reductions at a rate consistent with, or faster than, the reasonable progress goals of the Regional Haze Rule ("RHR"). Emissions from the majority of Hawaiʻi's electric generating plants are not a significant contributor to haze at Class I areas (for reasons explained in Appendix B). Further, their very low impact is being mitigated under the RPS state law. This rate of progress from the RPS law can be relied upon for further emissions reductions from EGUs in the coming years and thus separate further requirements for EGU controls under the RHR are not needed at this time. The following sections of this appendix provide a background on the RPS requirements and progress to date, and high confidence of continued progress consistent with the goals of the RHR.

2. Renewable Portfolio Standards

In 2002 the Hawaiʻi RPS legislation set voluntary goals for converting the islands' electrical generation from fossil fuels to renewable energy. In 2005, the RPS was set into law as binding requirements for Hawaiʻi electric utility companies. The law requires that electric utilities in Hawaiʻi achieve 100% of their electric generation from renewable energy sources by 2045 and meet a series of interim limits for the percentages of their electricity sales that must be provided by renewables (e.g., 30% renewable by 2020, and 40% by 2030, etc.). Renewable energy sources such as solar, hydro and wind energy have no direct emissions. Others such as biomass combustion have significantly lower emissions (especially sulfur dioxide ("SO_2")) than fossil fuels. Consequently, the RPS law results in steady progress in emissions reductions from electric utilities creating, in effect, an "RPS glidepath" providing dramatic reduction of electric generating unit emissions by mid-century.

The RPS program, although not directly related to the Regional Haze Rule ,is providing emissions reductions and improvements to air quality consistent with the goals of the RHR.

Table C-1 shows the interim and final RPS for EGUs along with the Regional Haze adjusted glidepath emissions reductions goals[1].

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[1] Regional Haze Adjusted Glidepath assumes consistent reductions in haze precursor emissions impacts from all U.S. anthropogenic sources from the baseline average of 2000-2004 to zero impacts in 2064, i.e. natural background.

Table C-1 Comparison of RPS and Regional Haze Glidepaths

Year	RPS Renewable Requirement % of Electricity Sales	Regional Haze Glidepath % Visibility Improvement
2010	10%	8%
2015	15%	17%
2020	30%	25%
2030	40%	42%
2040	70%	58%
2045	100%	67%
2065		100%

This table illustrates that the emissions reductions from EGUs under the RPS are similar to the visibility goals of the Regional Haze Program in the intermediate years and become much more stringent in later years. The RPS seeks to achieve 100% renewable electrical supply by 2045, which is twenty years earlier than the RHR target of 2065 to achieve natural background visibility in Class I areas.

3. Historical RPS Achievement

Hawaiian Electric[2], and other electric utility providers in Hawaiʻi, have made excellent progress in developing and supporting renewable energy sources. Figure C-1 below shows the percentage of all electrical sales statewide provided by renewable sources since the RPS inception (green columns).[3] It also shows as a line illustrating the RPS interim standards (with proportional progress assumed between RPS milestone years). This figure illustrates that Hawaiʻi EGUs have made significant progress to date and have been ahead of the RPS interim targets.

Hawaiian Electric represents majority of Hawaiʻi's electric generation. Figure C-2 shows the renewable energy source percentages for this same period specifically for Hawaiian Electric. The data follows the same trend as the statewide figures and this figure also shows a breakdown of the type of renewable energy technology used.

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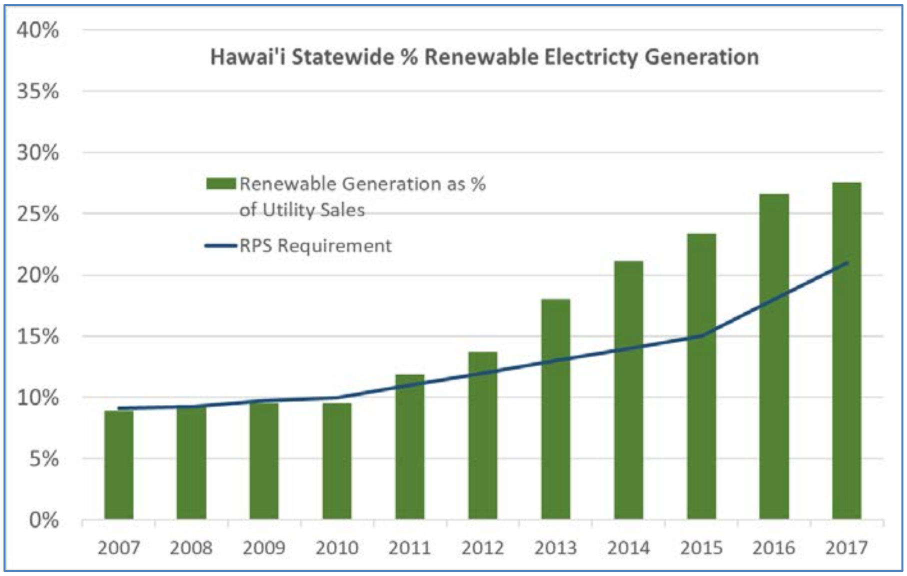
[2] "Hawaiian Electric" or the "Company" refers to Hawaiian Electric Company, Inc. (or "HE"), Hawaiʻi Electric Light Company, Inc. (or "HL") and/or Maui Electric Company, Limited (or "ME"). On December 20, 2019, the State of Hawaiʻi Department of Commerce and Consumer Affairs ("DCCA") approved Hawaiian Electric Company, Inc., Hawaiʻi Electric Light Company, Inc. and Maui Electric Company, Limited's application to do business under the trade name "Hawaiian Electric" for the period from December 20, 2019 to December 19, 2024. See Certificate of Registration No. 4235929, filed December 20, 2019 in the Business Registration Division of the DCCA.

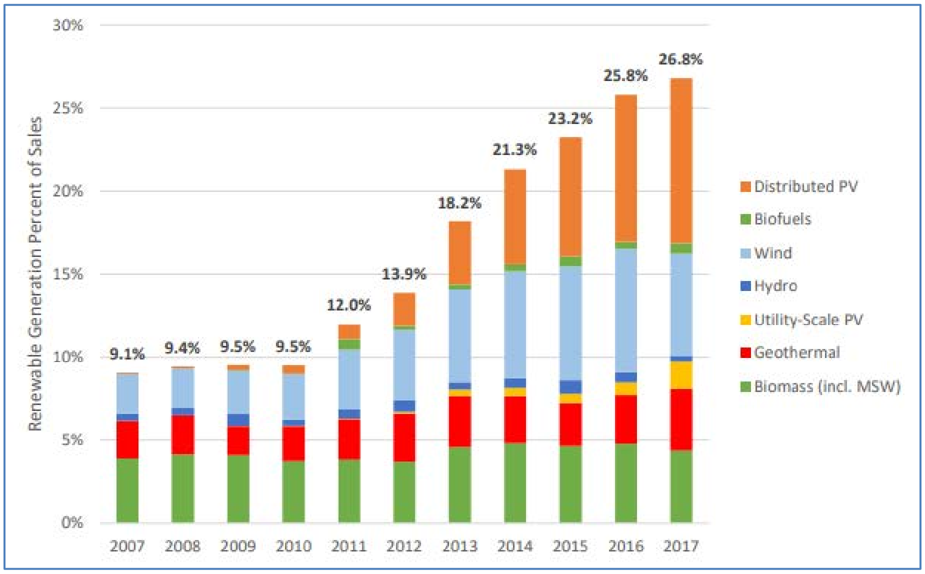
[3] *Hawaiʻi Public Utility Commission* (PUC), *"Report to the 2019 Legislature on Hawaiʻi's Renewable Portfolio Standards", Dec. 2018* https://puc.hawaii.gov/wp-content/uploads/2018/12/RPS-2018-Legislative-Report_FINAL.pdf.

Figure C-1 Statewide Renewable Portfolio Progress



Source: https://puc.Hawaii.gov/wp-content/uploads/2018/12/RPS-2018-Legislative-Report_FINAL.pdf

Figure C-2 Hawaiian Electric Companies RPS Achievement by Generation Technology[4]



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[4] PUC Dec. 2018 Report, Figure 2, page 7.

4. Future RPS Achievability

To date, Hawai'i's electric utilities have generally met or exceeded the RPS requirements. Continued progress consistent with RPS is expected to continue. Projects and plans are already in place to continue this rapid RPS shift to renewable energy sources for the period of interest of the next decadal period of the RHR. In its December 2018 report to the state legislature, the Hawai'i Public Utility Commission ("PUC") indicated that *"future renewable projects under construction or planned for the HECO Companies and KIUC should ensure that the state remains on track for meeting the 2020 and 2030 RPS targets."*[5]

Figure C-3 below shows Hawaiian Electric's projection of percent renewables through 2030 presented in the December 2018 PUC report. This projected progress remains well ahead of the RPS requirements which also is ahead of the requirements of the Regional Haze glidepath goals.

Figure C-3 Hawaiian Electric Companies RPS Expectation by 2030 Technology[6]

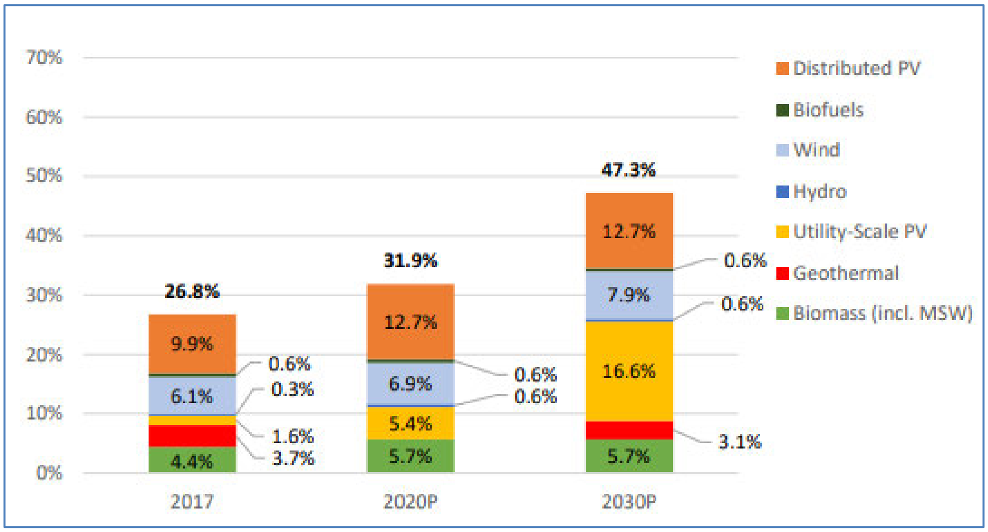

Table C-2 below shows the past actual and future forecast for Hawaiian Electric from the previous two figures (from PUC's 2018 report) together with the requirements of RPS and the goals of the RHR. Hawaiian Electric's renewable energy progress and forecast is ahead of both programs. Additionally, Hawaiian Electric has an internal target to achieve 100% renewables by 2040, five years ahead of the RPS requirement and 25 years ahead of the RHR goals.

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[5] PUC Dec. 2018 Report, page 2.

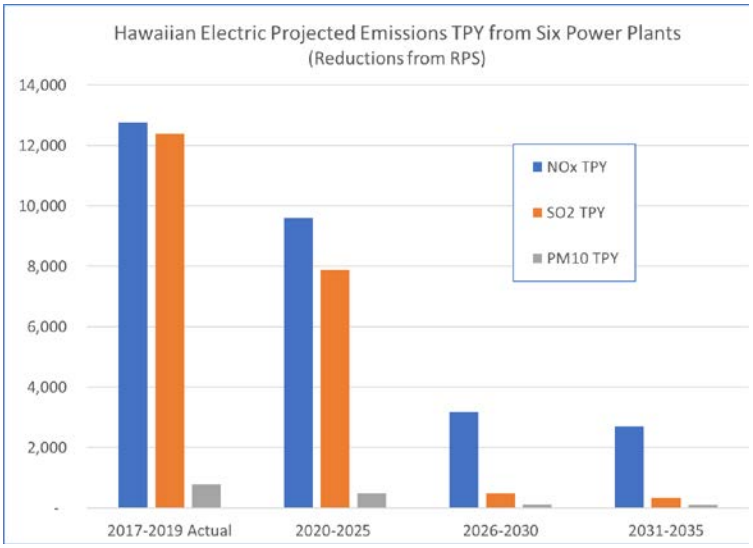
[6] PUC Dec. 2018 Report, Figure 2, page 16.

Table C-2 Comparison of RPS and Regional Haze Glidepaths

Year	RPS Renewable Requirement % of Electricity Sales	Regional Haze Glidepath % Visibility Improvement	Hawaiian Electric % Renewables
2010	10%	8%	9.5% (actual)
2015	15%	17%	23.2% (actual)
2020	30%	25%	31.9% (projection)
2030	40%	42%	47.3% (projection)
2040	70%	58%	100% (goal)
2045	100%	67%	100% (goal)

Hawaiian Electric's latest projections show an even more rapid shift to renewable energy sources than forecasted in 2018. This will continue to decrease Hawaiian Electric facility emissions. For example, Figure C-4 illustrates Hawaiian Electric's latest forecast emissions trends for total nitrogen oxides ("NOx"), sulfur dioxide ("SO_2") and Particulate Matter ("PM_{10}") emissions (in tons per year "TPY") from the six power plants (Waiau and Kahe Generating Stations on Oahu, Kahului and Maalaea on Maui, and Kanoelehua-Hill and Puna on Hawaiʻi) requested to conduct Four-Factor Analyses by the Hawaiʻi Department of Health ("DOH"). These dramatic emissions decreases illustrate the expected progress from RPS alone – without any additional RHR measures The forecast emissions shown in Figure C-4 was derived from recent fuel consumption projections based on the resource plans and planning assumptions submitted to the PUC as part of Hawaiian Electric's 2016 Power Supply Improvement Plan ("PSIP") which was accepted by the PUC and recent renewable project applications.

Figure C-4 Hawaiian Electric NOx Forecast Emissions



The emissions reduction is quite rapid and most of the projected reduction by Hawaiian Electric are expected to be in place prior to 2028, the next Regional Haze planning milestone.

Although this projection is based on reasonable assumptions, plans are subject to change as there is some uncertainty regarding future projections and forecast assumptions. For this reason and due to energy security issues, Hawaiian Electric cannot commit to specific dates for particular emissions reductions or final retirements of any specific generating station. Nevertheless, Hawaiian Electric is on an aggressive path to end fossil-fueled generation and replace it with renewable energy sources – especially during this next decadal period. This progress should be sufficient for Hawaiian Electric's contribution to the state's efforts regarding reasonable progress of the RHR for the current Regional Haze decadal review.

5. Reliance on RPS for this Regional Haze Decadal Review

The RPS requirements are part of Hawaiʻi state law. An electric utility failing to meet the RPS requirements is subject to enforcement action and penalties by the PUC unless the PUC determines the electric utility is unable to meet the RPS due to factors beyond its reasonable control. However, given the progress to date of the Hawaiʻi electric utilities acquiring renewable generation and expectations for planned renewable projects in the near future, it is reasonable to expect that RPS will result in continued steady progress, at least through 2030.

The DOH can rely on the RPS for regional haze progress without having to impose separate RHR requirements in facility permits. This is supported by EPA guidance which states that "Enforceable requirements are one reasonable basis for projecting a change in operating parameters and thus emissions; energy efficiency, renewable energy, or other such programs where there is a documented commitment to participate and verifiable basis for quantifying any change in future emissions due to operational changes may be another."[7]

Even if progress were slower than currently expected, it would not prevent the RPS from being relied upon as the major EGU contribution to meeting Hawaiʻi's regional haze goals. The time perspective of the Regional Haze Program is long. Making wise decisions that help achieve the long-term goals is important. Hawaiʻi electric utilities are currently focusing resources on advancing renewable energy projects that will permanently displace fossil-fueled unit generation and fossil-fueled combustion emissions. These ongoing RPS efforts help achieve the long-term goals of the RHR and provide permanent emissions reductions and other societal benefits. In contrast, new investments in conventional emissions controls on aging fossil-fueled units provide only modest short-term benefits impose additional costs on rate payers and will have no lasting value when those units are deactivated or retired.

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[7] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period – August 2019 at page 17. https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf.

APPENDIX D : FUEL COST

Appendix Table D-1. Ultra-Low Sulfur Diesel (ULSD) Import Cost

Description	Value	Units
Platts 2018 Price [A]	86.75	$/BBL
2019 Inflation	1.5	%
Platts 2019 Price	88.05	$/BBL
Freight [B]	5.51	$/BBL
Terminalling Fee [B]	2.00	$/BBL
Total ULSD Import Cost [C]	**95.56**	**$/BBL**
	2.28	**$/Gal**

[A] S&P Global Platts - Oilgram Price Report, listed price is Singapore spot price for Gasoil 10 ppm which is comparable to ULSD. (https://www.spglobal.com/platts/plattscontent/_assets/_files/en/productsservices/market-reports/oilgram-proce-report-060818.pdf)

[B] Hawaiian Electric Fuels Division Estimate.

[C] Platts 2019 spot price plus freight and terminalling fees.

Appendix Table D-2. Diesel (0.4% Maximum Sulfur) Import Cost

Description	Value	Units
Platts 2018 Price [A]	85.12	$/BBL
2019 Inflation	1.5	%
Platts 2019 Price	86.40	$/BBL
Freight [B]	5.51	$/BBL
Terminalling Fee [B]	2.00	$/BBL
Total ULSD Import Cost [C]	**93.91**	**$/BBL**
	2.24	**$/Gal**

[A] S&P Global Platts - Oilgram Price Report, listed price is Singapore spot price for Gasoil 0.25% S which is comparable to the current diesel supply.

(https://www.spglobal.com/platts/plattscontent/_assets/_files/en/productsservices/market-reports/oilgram-proce-report-060818.pdf)

[B] Hawaiian Electric Fuels Division Estimate.

[C] Platts 2019 spot price plus freight and terminalling fees.

Control Cost Worksheets and DOH-CAB Revisions

Changes Summarized

3.25 % interest rate for controls

30 year equipment life for SCR

20 year equipment life for all other controls

SCR retrofit factor of 1

Hawaii Island Construction Cost Multiplier from 1.84 to 1.0

Table 3-1. 2017 Fuel Property and Fuel Usage and Baseline SO_2 Emissions

		2017 Annual Average Fuel Properties [A]			Annual Fuel Usage [B]		SO_2 Emissions	
Unit	Primary Fuel	Sulfur Content	HHV (Btu/gal)	Density (lb/gal)	Volume (gal/yr)	Heat Input (MMBtu/yr)	(lb/MMBtu) [C]	(TPY) [D]
M1	ULSD	0.0005%	137,934	7.04	45,180	6,232	4.71E-04	1.47E-03
M2	ULSD	0.0005%	137,934	7.04	26,309	3,629	4.71E-04	8.54E-04
M3	ULSD	0.0005%	137,934	7.04	45,123	6,224	4.71E-04	1.46E-03
M4	Diesel	0.0567%	137,169	6.97	368,268	50,515	0.0576	1.5
M5	Diesel	0.0567%	137,169	6.97	280,704	38,504	0.1039	2.0
M6	Diesel	0.0567%	137,169	6.97	278,524	38,205	0.0576	1.1
M7	Diesel	0.0567%	137,169	6.97	313,927	43,061	0.0975	2.1
M8	Diesel	0.0567%	137,169	6.97	279,114	38,286	0.0576	1.1
M9	Diesel	0.0567%	137,169	6.97	465,609	63,867	0.0576	1.8
M10	Diesel	0.0567%	137,169	6.97	2,933,686	402,410	0.0576	11.6
M11	Diesel	0.0567%	137,169	6.97	2,565,572	351,916	0.0576	10.1
M12	Diesel	0.0567%	137,169	6.97	2,882,514	395,391	0.0576	11.4
M13	Diesel	0.0567%	137,169	6.97	2,784,528	381,950	0.0576	11.0
X1	ULSD	0.0005%	137,934	7.04	47,215	6,513	0.0005	1.53E-03
X2	ULSD	0.0005%	137,934	7.04	47,455	6,546	0.0005	1.54E-03
M14	Diesel	0.0567%	137,169	6.97	8,037,944	1,102,554	0.0576	31.7
M16	Diesel	0.0567%	137,169	6.97	9,394,316	1,288,606	0.0576	37.1
M17	Diesel	0.0567%	137,169	6.97	8,435,032	1,157,022	0.1017	58.8
M19	Diesel	0.0567%	137,169	6.97	7,612,681	1,044,222	0.1031	53.8
							Total	**235.2**

[A] Calendar year 2017 annual average fuel properties from company records.

[B] Calendar annual fuel usage from company records.

[C] The SO_2 emission factors for units M1-M4, M6, M8-M16 and X1 and X2 are based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average fuel density (7.04 lb/gal for ULSD; 6.97 lb/gal for diesel) and higher heating value (137,933 Btu/gal for ULSD; 137,169 Btu/gal for diesel). The SO_2 emission factors for units M5, M7, M17 and M19 are based the monthly reported emissions on the 2017 Annual Emissions Report Forms; Diesel Engine Generators Units M5 and M7 and Combustion Turbine Generators Units M17 and M19.

[D] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Table 4-1 Baseline NO_X Emissions

	NO_X Emissions	
Unit	(lb/MMBtu) [A]	(TPY) [B]
M1	3.200	10.0
M2	3.200	5.8
M3	3.200	10.0
M4	3.200	80.8
M5	4.296	82.7
M6	3.200	61.1
M7	5.708	122.9
M8	3.200	61.3
M9	3.200	102.2
M10	2.884	580.3
M11	2.877	506.2
M12	2.027	405.9
M13	2.171	419.5
X1	1.586	5.2
X2	1.614	5.3
M14	0.155	85.4
M16	0.153	98.6
M17	0.133	76.7
M19	0.127	66.4
	Total	**2,786.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Table 5-1 Baseline PM_{10} Emissions

	PM_{10} Emissions	
Unit	(lb/MMBtu) [A]	(TPY) [B]
M1	0.0573	0.2
M2	0.0573	0.1
M3	0.0573	0.2
M4	0.0573	1.4
M5	0.0573	1.1
M6	0.0573	1.1
M7	0.0573	1.2
M8	0.0573	1.1
M9	0.0573	1.8
M10	0.0540	10.9
M11	0.0540	9.5
M12	0.0949	19.0
M13	0.0989	19.1
X1	0.0573	0.2
X2	0.0573	0.2
M14	0.0267	14.7
M16	0.0460	29.6
M17	0.0292	16.9
M19	0.0307	16.0
Total		**144.3**

[A] Calendar year 2017 emission factors from the 2018 Emissions Fee Report.

[B] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

Original Submitted Spreadsheet

Maalaea Generating Station

Calculated

2017 Maalaea Fuel Analyses Summary

Destination	Fuel	Time Period	Volume Received (bbls)	Sulfur Content Maximum (wt. %)	Sulfur Content Average (wt. %)	Average Nitrogen Content (wt. %)	Average Higher Heating Value (Btu/gal)	Average Density (lb/gal)	# of Shipments
Maalaea	Diesel	Jan - Jun	562,537	0.26	0.06	0.00500			25
		Jul - Dec	518,137	0.07	0.05	0.00483			23
		Jan - Dec	1,080,674	0.26	0.06	0.00492	137,169	6.97	48
	ULSD	Jan - Jun	115,931	0.0007	0.0003				13
		Jul - Dec	89,218	0.0009	0.0007				3
		Jan - Dec	205,149	0.0009	0.0005		137,934	7.04	16
	Biodiesel	Jan - Jun		--	--				0
		Jul - Dec		0.0010	0.0010				1
		Jan - Dec		0.0010	0.0010		125,690	7.34	1

Note - Averages for diesel are weighted based on the size of the fuel shipment.

Supporting Data

Design Heat Input (MMBtu/hr)	Design Output Nominal (MW)	Biodiesel (Gal)	Biodiesel (MMBtu)
29.2	2.5		
29.2	2.5		
29.2	2.5		
58.8	5.6		
58.8	5.6		
58.8	5.6		
58.8	5.6		
60.2	5.6		
122.7	12.5		
122.7	12.5		
122.7	12.5	40,240	5,058
122.7	12.5	36,231	4,554
28.5	2.5		
28.5	2.5		
275	20		
275	20		
275	20		
275	20		

D
25.5

Original Submitted Spreadsheet

Table 3-2. SO_2 Cost Effectiveness of Switching to ULSD

	Current Diesel (0.4% Maximum Sulfur) [A]					ULSD (0.0015% maximum Sulfur) [B]						
Unit	2017 Average Sulfur Content	Fuel Heating Value (HHV) (Btu/gal)	Annual Fuel Usage (gal/yr)	2017 Annual Heat Input (MMBtu/yr)	2017 SO_2 Emissions [C] (tpy)	Fuel Heating Value (HHV) (Btu/gal)	Annual Fuel Usage (gal/yr)	Controlled SO_2 Emissions (tpy)	SO_2 Reduced (tpy)	Fuel Cost Differential [D] ($/Gal)	Fuel Cost Differential [D] ($/yr)	SO_2 Cost Effectiveness ($/ton)
M4	0.0567%	137,169	368,268	50,515	1.5	137,934	366,225	0.04	1.42	0.04	14,649	10,347
M5	0.0567%	137,169	280,704	38,504	1.1	137,934	279,147	0.03	1.08	0.04	11,166	10,347
M6	0.0567%	137,169	278,524	38,205	1.1	137,934	276,979	0.03	1.07	0.04	11,079	10,347
M7	0.0567%	137,169	313,927	43,061	1.2	137,934	312,185	0.03	1.21	0.04	12,487	10,347
M8	0.0567%	137,169	279,114	38,286	1.1	137,934	277,566	0.03	1.07	0.04	11,103	10,347
M9	0.0567%	137,169	465,609	63,867	1.8	137,934	463,026	0.05	1.79	0.04	18,521	10,347
M10	0.0567%	137,169	2,933,686	402,410	11.6	137,934	2,917,409	0.31	11.28	0.04	116,696	10,347
M11	0.0567%	137,169	2,565,572	351,916	10.1	137,934	2,551,338	0.27	9.86	0.04	102,054	10,347
M12	0.0567%	137,169	2,882,514	395,391	11.4	137,934	2,866,521	0.30	11.08	0.04	114,661	10,347
M13	0.0567%	137,169	2,784,528	381,950	11.0	137,934	2,769,078	0.29	10.71	0.04	110,763	10,347
M14	0.0567%	137,169	8,037,944	1,102,554	31.7	137,934	7,993,347	0.84	30.90	0.04	319,734	10,347
M16	0.0567%	137,169	9,394,316	1,288,606	37.1	137,934	9,342,193	0.99	36.12	0.04	373,688	10,347
M17	0.0567%	137,169	8,435,032	1,157,022	33.3	137,934	8,388,232	0.89	32.43	0.04	335,529	10,347
M19	0.0567%	137,169	7,612,681	1,044,222	30.1	137,934	7,570,443	0.80	29.27	0.04	302,818	10,347

[A] Based on 2017 average fuel properties and fuel usage.

[B] Based on 2017 average HHV and density for ULSD and contract fuel sulfur limit.

[C] The listed annual SO_2 emissions from M5, M7, M17, and M19 are based on based on 100% conversion of fuel sulfur to SO_2 and the calendar year 2017 annual average diesel fuel density (6.97 lb/gal) and higher heating value (137,169). The listed 2017 annual SO_2 emissions from the remaining units are from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[D] See Appendix D for fuel cost.

Summary Calculations Below

Total	20-yr Total
$1,850,000	$37,000,000

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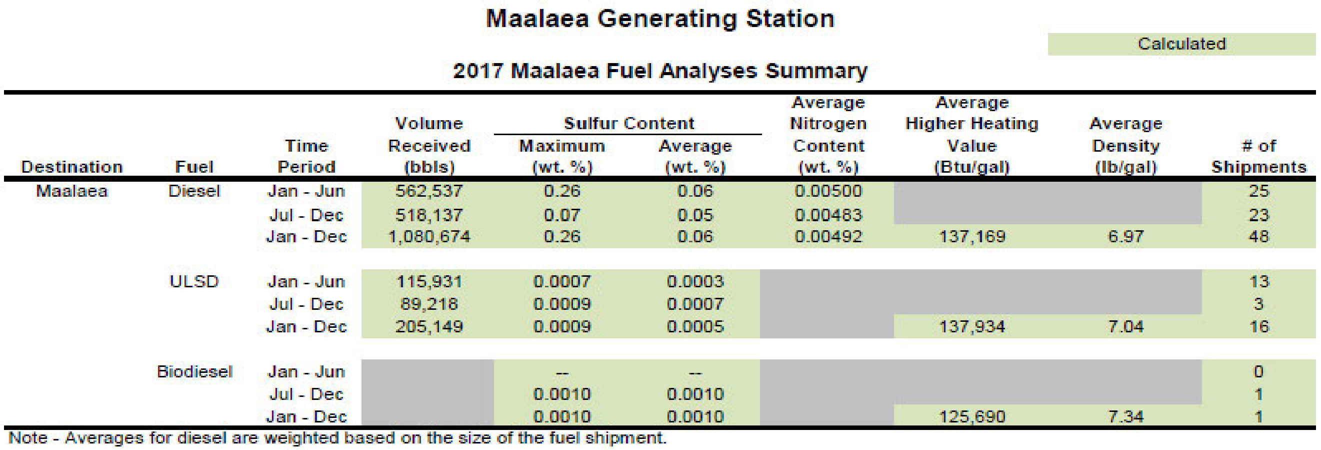
Supporting Data

Appendix D Cost

	Diesel		ULSD		Fuel Cost Differential
Year	$/bbl	$/gal	$/bbl	$/gal	$/gal
2019	94.08	2.24	95.76	2.28	0.04

	2017 Average		
	HHV (Btu/gal)	Density (lb/gal)	SO_2 EF (lb/MMBtu)
ULSD (15 ppm)	137,934	7.04	0.00153



Maalaea Generating Station

🟩 Calculated

2017 Maalaea Fuel Analyses Summary

Destination	Fuel	Time Period	Volume Received (bbls)	Sulfur Content		Average Nitrogen Content (wt. %)	Average Higher Heating Value (Btu/gal)	Average Density (lb/gal)	# of Shipments
				Maximum (wt. %)	Average (wt. %)				
Maalaea	Diesel	Jan - Jun	562,537	0.26	0.06	0.00500			25
		Jul - Dec	518,137	0.07	0.05	0.00483			23
		Jan - Dec	1,080,674	0.26	0.06	0.00492	137,169	6.97	48
	ULSD	Jan - Jun	115,931	0.0007	0.0003				13
		Jul - Dec	89,218	0.0009	0.0007				3
		Jan - Dec	205,149	0.0009	0.0005		137,934	7.04	16
	Biodiesel	Jan - Jun		--	--				0
		Jul - Dec		0.0010	0.0010				1
		Jan - Dec		0.0010	0.0010		125,690	7.34	1

Note - Averages for diesel are weighted based on the size of the fuel shipment.

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Table 4-2. NO_X Cost Effectiveness of FITR

	Design Nominal Output (MW)	Control Option	2017 NO_X Emissions [A] (tpy)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Cost [B] ($)	Capital Recovery Factor [C]	Annualized Capital Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.09	20,795	4,159
M2	2.5	FITR	5.8	50%	2.9	2.9	220,304	0.09	20,795	7,171
M3	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.09	20,795	4,159

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed capital cost is the total installed cost of an EMD Tier II Pack Update from a 2012 vendor quote. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.09 Where: I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

[D] Capital Cost x CRF

Summary Calculations Below

Cost Effectiveness

Min =	4,200
Max =	7,200

Life	Interest %
20	7

Total	**20-yr Total**
$60,000	$1,200,000

Cost Index: Chemical Engineering Plant Cost Index (CEPCI)

2019	607.5
2012	584.6

Original Submitted Spreadsheet

Table 4-2. NO_X Cost Effectiveness of FITR

	Design Nominal Output (MW)	Control Option	2017 NO_X Emissions [A] (tpy)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Cost [B] ($)	Capital Recovery Factor [C]	Annualized Capital Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.07	15,152	3,030
M2	2.5	FITR	5.8	50%	2.9	2.9	220,304	0.07	15,152	5,225
M3	2.5	FITR	10.0	50%	5.0	5.0	220,304	0.07	15,152	3,030

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed capital cost is the total installed cost of an EMD Tier II Pack Update from a 2012 vendor quote. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]   CRF = 0.07   Where: I = Interest Rate (3.25% interest)
a = Equipment life (20 yrs)

[D] Capital Cost x CRF

Summary Calculations Below

Cost Effectiveness	
Min =	3,000
Max =	5,200

Life	Interest %
20	3.25

Total	**20-yr Total**
$50,000	$1,000,000

Cost Index: Chemical Engineering Plant Cost Index (CEPCI)

2019	607.5
2012	584.6

DOH-CAB Changed Spreadsheet

Table 4-3. NO_X Cost Effectiveness of SCR on the Maalaea Diesel Engine Generators

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 NO_X Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Recovery [B] ($)	Annual Operating Cost [C] ($)	Total Annualized Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	3,600	SCR	10.0	346.4	90%	1.0	9.0	124,691	49,755	174,446	19,383
M2	2.5	3,600	SCR	5.8	206.8	90%	0.6	5.2	124,691	29,703	154,395	29,578
M3	2.5	3,600	SCR	10.0	340.9	90%	1.0	9.0	124,691	48,965	173,656	19,295
M4	5.6	7,762	SCR	80.8	1,698.0	90%	8.1	72.7	279,309	525,853	805,161	11,072
M5	5.6	7,762	SCR	82.7	1,110.0	90%	8.3	74.4	279,309	343,755	623,064	8,371
M6	5.6	7,762	SCR	61.1	1,252.0	90%	6.1	55.0	279,309	387,731	667,040	12,130
M7	5.6	7,762	SCR	122.9	1,299.0	90%	12.3	110.6	279,309	402,287	681,595	6,162
M8	5.6	7,798	SCR	61.3	1,257.0	90%	6.1	55.2	279,309	391,085	670,394	12,151
M9	5.6	7,798	SCR	102.2	1,929.0	90%	10.2	92.0	279,309	600,162	879,470	9,562
M10	12.5	17,520	SCR	580.3	5,335.8	90%	58.0	522.3	623,457	3,729,808	4,353,265	8,335
M11	12.5	17,520	SCR	506.2	4,677.7	90%	50.6	455.6	623,457	3,269,786	3,893,242	8,546
M12	12.5	17,520	SCR	405.9	5,291.4	90%	40.6	365.3	623,457	3,698,772	4,322,228	11,832
M13	12.5	17,520	SCR	419.5	4,944.2	90%	42.0	377.6	623,457	3,456,073	4,079,530	10,805
X1	2.5	3,600	SCR	5.2	235.0	90%	0.5	4.7	124,691	33,754	158,445	33,856
X2	2.5	3,600	SCR	5.3	228.6	90%	0.5	4.8	124,691	32,835	157,526	33,024

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Capital recovery is based on a cost of $49,877 per MW based on an 2012 internal egneering report for units M5 - M9. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[C] Annual operating cost is based on a cost of $0.0399 per engine horsepower per operating hour based on EPA costing. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[D] Total Annualized Cost = Capital Recovery + Annual Operating Cost

Supporting and Summary Calculations Below

Appendix A Cost

Capital Recovery ($/MW)	Annual Operating Cost ($/Hp/hr)
49,877	0.0399

Cost Effectiveness

Min =	6,200
Max =	33,900

Total	20-yr Total
22,000,000	440,000,000

Original Submitted Spreadsheet

Table 4-3. NO_X Cost Effectiveness of SCR on the Maalaea Diesel Engine Generators

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 NO_X Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Capital Recovery [B] ($)	Annual Operating Cost [C] ($)	Total Annualized Cost [D] ($)	NO_X Cost Effectiveness ($/ton)
M1	2.5	3,600	SCR	10.0	346.4	90%	1.0	9.0	69,592	56,369	125,960	13,996
M2	2.5	3,600	SCR	5.8	206.8	90%	0.6	5.2	69,592	33,652	103,244	19,778
M3	2.5	3,600	SCR	10.0	340.9	90%	1.0	9.0	69,592	55,474	125,065	13,896
M4	5.6	7,762	SCR	80.8	1,698.0	90%	8.1	72.7	155,885	595,757	751,642	10,336
M5	5.6	7,762	SCR	82.7	1,110.0	90%	8.3	74.4	155,885	389,453	545,338	7,327
M6	5.6	7,762	SCR	61.1	1,252.0	90%	6.1	55.0	155,885	439,274	595,160	10,823
M7	5.6	7,762	SCR	122.9	1,299.0	90%	12.3	110.6	155,885	455,765	611,650	5,530
M8	5.6	7,798	SCR	61.3	1,257.0	90%	6.1	55.2	155,885	443,074	598,959	10,857
M9	5.6	7,798	SCR	102.2	1,929.0	90%	10.2	92.0	155,885	679,945	835,830	9,087
M10	12.5	17,520	SCR	580.3	5,335.8	90%	58.0	522.3	347,958	4,225,632	4,573,590	8,757
M11	12.5	17,520	SCR	506.2	4,677.7	90%	50.6	455.6	347,958	3,704,456	4,052,414	8,895
M12	12.5	17,520	SCR	405.9	5,291.4	90%	40.6	365.3	347,958	4,190,470	4,538,428	12,423
M13	12.5	17,520	SCR	419.5	4,944.2	90%	42.0	377.6	347,958	3,915,508	4,263,466	11,292
X1	2.5	3,600	SCR	5.2	235.0	90%	0.5	4.7	69,592	38,241	107,832	23,041
X2	2.5	3,600	SCR	5.3	228.6	90%	0.5	4.8	69,592	37,199	106,791	22,388

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Capital recovery is based on a cost of $27,837 per MW based on an 2012 internal egneering report for units M5 - M9. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[C] Annual operating cost is based on a cost of $0.0452 per engine horsepower per operating hour based on EPA costing. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index. See Appendix A for the calculation details.

[D] Total Annualized Cost = Capital Recovery + Annual Operating Cost

Supporting and Summary Calculations Below

Appendix A Cost	
Capital Recovery ($/MW)	Annual Operating Cost ($/Hp/hr)
27,837	0.0452

Cost Effectiveness

Min =	5,500
Max =	23,000

Total	20-yr Total
22,000,000	440,000,000

DOH-CAB Changed Spreadsheet

Table 4-4. NO_X Cost Effectiveness of Adding SCR Maalaea Combustion Turbine Generators

	Control Option	2017 NO_X Emissions [A] (tpy)	Controlled Emission Rate [B] (ppmvd @ 15% O_2)	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Annualized Cost [C] ($)	NO_X Cost Effectiveness ($/ton)
M14	SCR	85.4	15	54.9	30.5	1,842,606	60,413
M16	SCR	98.6	15	63.4	35.2	1,842,606	52,326
M17	SCR	76.7	15	49.3	27.4	1,842,606	67,266
M19	SCR	66.4	15	42.7	23.7	1,842,606	77,700

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Controlled emissions are based on the ratio of the permit limit of 42 ppmvd @ 15% O_2 to the listed controlled emission rate.

[C] The annual SCR cost is documented in Appendix A. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index.

Summary Calculations Below

Cost Effectiveness

Min =	$ 52,300
Max =	$ 77,700

Total	20-yr Total
$7,400,000	$148,000,000

Original Submitted Spreadsheet

Table 4-4. NO_X Cost Effectiveness of Adding SCR Maalaea Combustion Turbine Generators

	Control Option	2017 NO_X Emissions [A] (tpy)	Controlled Emission Rate [B] (ppmvd @ 15% O_2)	Controlled NO_X Emissions (tpy)	NO_X Reduced (tpy)	Annualized Cost [C] ($)	NO_X Cost Effectiveness ($/ton)
M14	SCR	85.4	15	54.9	30.5	727,535	23,854
M16	SCR	98.6	15	63.4	35.2	727,535	20,660
M17	SCR	76.7	15	49.3	27.4	727,535	26,559
M19	SCR	66.4	15	42.7	23.7	727,535	30,679

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] Controlled emissions are based on the ratio of the permit limit of 42 ppmvd @ 15% O_2 to the listed controlled emission rate.

[C] The annual SCR cost is documented in Appendix A. The cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index.

Summary Calculations Below

Cost Effectiveness	
Min =	$ 20,700
Max =	$ 30,700

Total	20-yr Total
$2,900,000	$58,000,000

DOH-CAB Changed Spreadsheet

Table 5-2. PM_{10} Cost Effectiveness of Diesel Particulate Filters

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 PM_{10} Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled PM_{10} Emissions (tpy)	PM_{10} Reduced (tpy)	Incremental Capital Cost [B] ($)	Capital Recovery Factor [C]	Incremental Annualized Capital Cost [D] ($)	PM_{10} Cost Effectiveness ($/ton)
M4	5.6	7,762	DPF	1.4	1,698.0	85%	0.2	1.2	519,586	0.09	49,045	41,214
M5	5.6	7,762	DPF	1.1	1,110.0	85%	0.2	0.9	519,586	0.09	49,045	52,455
M6	5.6	7,762	DPF	1.1	1,252.0	85%	0.2	0.9	519,586	0.09	49,045	52,455
M7	5.6	7,762	DPF	1.2	1,299.0	85%	0.2	1.0	519,586	0.09	49,045	48,084

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed incremental capital cost is based on the incremental capital cost of adding a DPF to the SCR installation. The SCR and SCR+DPF capital cost are from an 2012 internal engineering report for units M5 - M9. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.09 Where: I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

[D] Incremental Capital Cost x CRF

Summary Calculations Below

Life	Interest %
20	7

Cost Effectiveness

Min =	$ 41,200
Max =	$ 52,500

Cost Index: Chemical Engineering Plant Cost Index (CEPCI)

2019	607.5
2012	584.6

Total	**20-yr Total**
$200,000	$4,000,000

Original Submitted Spreadsheet

Table 5-2. PM_{10} Cost Effectiveness of Diesel Particulate Filters

	Design Nominal Output (MW)	Nominal Engine Power (Hp)	Control Option	2017 PM_{10} Emissions [A] (tpy)	2017 Operating Hours (hrs/yr)	Control Efficiency	Controlled PM_{10} Emissions (tpy)	PM_{10} Reduced (tpy)	Incremental Capital Cost [B] ($)	Capital Recovery Factor [C]	Incremental Annualized Capital Cost [D] ($)	PM_{10} Cost Effectiveness ($/ton)
M4	5.6	7,762	DPF	1.4	1,698.0	85%	0.2	1.2	519,586	0.07	35,737	30,031
M5	5.6	7,762	DPF	1.1	1,110.0	85%	0.2	0.9	519,586	0.07	35,737	38,221
M6	5.6	7,762	DPF	1.1	1,252.0	85%	0.2	0.9	519,586	0.07	35,737	38,221
M7	5.6	7,762	DPF	1.2	1,299.0	85%	0.2	1.0	519,586	0.07	35,737	35,036

[A] Calendar year 2017 actual emissions from the 2018 Criteria Pollutant Annual Fee Summary for Covered Sources (Form F-1CP).

[B] The listed incremental capital cost is based on the incremental capital cost of adding a DPF to the SCR installation. The SCR and SCR+DPF capital cost are from an 2012 internal engineering report for units M5 - M9. The 2012 cost has been scaled to 2019 dollars using the Chemical Engineering Plant Cost Index (607.5/548.6).

[C] Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.07 Where:

I = Interest Rate (3.25% interest)

a = Equipment life (20 yrs)

[D] Incremental Capital Cost x CRF

Summary Calculations Below

Life	Interest %
20	3.25

Cost Effectiveness

Min =	$	30,000
Max =	$	38,200

Cost Index: Chemical Engineering Plant Cost Index (CEPCI)

2019	607.5
2012	584.6

Total	**20-yr Total**
$100,000	$2,000,000

DOH-CAB Changed Spreadsheet

Appendix Table A-1. SCR Capital and Annual Cost Estimates - Diesel Engine Generators

			Table 5-6
Capital Recovery Factor (CRF)			0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
2019		607.5	
2005		468.2	
Capital Cost (2010 dollars)	($/Hp)		$98
Capital Cost (2019 dollars)	($/Hp)		$127
Annualized Capital Cost (2019 dollars)	($/Hp)		$12
Total Annual Cost Including Capital Recovery (2005 dollars)	($/Hp based on 1000 hrs/yr)		$40
Total Annual Cost Including Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$52
Total Annual Cost Minus Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$40
Annual Operating Cost (2019 Dollars)	**($/Hp/Hr)**		**$0.0399**

Source: *Assessment of Non-EGU NO $_X$ Emission Controls, Cost of Controls, and Time for Compliance*, Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

			M5-M9 Estimate
M5 - M9 Nominal Design Output	(MW)		5.9
Capital Recovery Factor (CRF)			0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
2019		607.5	
2012		584.6	
Capital Cost (2012 dollars)	($)		$3,000,000
	($/MW)		$508,475
Capital Cost (2019 dollars)	($/MW)		$528,392.58
Annualized Capital Cost (2019 dollars)	**($/MW)**		**$49,877**

Source: *2012 Internal Engineering Study*

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]

CRF = 0.09

Where:

I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

Life	Interest %
20	7

Original Submitted Spreadsheet

Appendix Table A-1. SCR Capital and Annual Cost Estimates - Diesel Engine Generators

			Table 5-6
Capital Recovery Factor (CRF)			0.05
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2019	607.5	
	2005	468.2	
Capital Cost (2010 dollars)	($/Hp)		$98
Capital Cost (2019 dollars)	($/Hp)		$127
Annualized Capital Cost (2019 dollars)	($/Hp)		$7
Total Annual Cost Including Capital Recovery (2005 dollars)	($/Hp based on 1000 hrs/yr)		$40
Total Annual Cost Including Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$52
Total Annual Cost Minus Capital Recovery (2019 dollars)	($/Hp based on 1000 hrs/yr)		$45
Annual Operating Cost (2019 Dollars)	**($/Hp/Hr)**		**$0.0452**

Source: *Assessment of Non-EGU NO_X Emission Controls, Cost of Controls, and Time for Compliance*, **Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015**

			M5-M9 Estimate
M5 - M9 Nominal Design Output	(MW)		5.9
Capital Recovery Factor (CRF)			0.05
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)			
	2019	607.5	
	2012	584.6	
Capital Cost (2012 dollars)	($)		$3,000,000
	($/MW)		$508,475
Capital Cost (2019 dollars)	($/MW)		$528,392.58
Annualized Capital Cost (2019 dollars)	**($/MW)**		**$27,837**

Source: *2012 Internal Engineering Study*

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1]

CRF = 0.05

Where:

I = Interest Rate (3.25% interest)

a = Equipment life (30 yrs)

Life	Interest %
30	3.25

DOH-CAB Changed Spreadsheet

Appendix Table A-2. SCR Capital and Total Annual Cost Estimate - Combustion Turbines

		M14	M16	M17	M19
MW		20.0	20.0	20.0	20.0
Max Heat Input	(MMBtu/hr)	275	275	275	275
Capital Recovery Factor (CRF)		0.09	0.09	0.09	0.09
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)					
2019	605.7				
1990	357.6				
Total Capital Investment (Eq. 1 - 1990 dollars)	($)	$1,672,762	$1,672,762	$1,672,762	$1,672,762
Capital Cost (2019 dollars)	($)	$2,833,311	$2,833,311	$2,833,311	$2,833,311
Annualized Capital Cost (2019 dollars)	($/yr)	$267,444	$267,444	$267,444	$267,444
Total Annual Cost (Eq. 2 - 1990 dollars)	($/yr)	$561,331	$561,331	$561,331	$561,331
Total Annual Cost (2019 dollars)	($/yr)	$950,777	$950,777	$950,777	$950,777
Maui Construction Cost Multiplier [A]		1.938	1.938	1.938	1.938
Total Annual Cost (2019 Dollars)	**($/yr)**	**$1,842,606**	**$1,842,606**	**$1,842,606**	**$1,842,606**

Total capital investment (1990 dollars) = 4744 x (MMBtu/hr) + 368162 Equation 1

Total Annual Cost (1990 dollars) = 1522.5 x (MMBtu/hr) + 142643 Equation 2

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.09

Where:

I = Interest Rate (7% interest)
a = Equipment life (20 yrs)

Source: *Assessment of Non-EGU NO$_X$ Emission Controls, Cost of Controls, and Time for Compliance*, **Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015**

[A] **The Maui construction cost multiplier is based on cost of construction geographical multipliers from the** ***RSMeans Mechanical Cost Data 2016 to account for factors unique to Maui's location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.***

Life	Interest %
20	7

Original Submitted Spreadsheet

Appendix Table A-2. SCR Capital and Total Annual Cost Estimate - Combustion Turbines

		M14	**M16**	**M17**	**M19**
MW		20.0	20.0	20.0	20.0
Max Heat Input	(MMBtu/hr)	275	275	275	275
Capital Recovery Factor (CRF)		0.05	0.05	0.05	0.05
Cost Index: Chemical Engineering Plant Cost Index (CEPCI)					
2019	605.7				
1990	357.6				
Total Capital Investment (Eq. 1 - 1990 dollars)	($)	$1,672,762	$1,672,762	$1,672,762	$1,672,762
Annualized Capital Cost (1990 dollars, 15 yrs @ 10%)	($/yr)	$219,924	$219,924	$219,924	$219,924
Capital Cost (2019 dollars)	($)	$2,833,311	$2,833,311	$2,833,311	$2,833,311
Annualized Capital Cost (2019 dollars)	($/yr)	$149,264	$149,264	$149,264	$149,264
Total Annual Cost (Eq. 2 - 1990 dollars, 15 yrs @ 10%)	($/yr)	$561,331	$561,331	$561,331	$561,331
Annual Operating Cost (1990 dollars)	($/yr)	$341,406	$341,406	$341,406	$341,406
Annual Operating Cost (2019 dollars)	($/yr)	$578,271	$578,271	$578,271	$578,271
Total Annual Cost (2019 dollars)	($/yr)	$727,535	$727,535	$727,535	$727,535
Maui Construction Cost Multiplier [A]		1.000	1.000	1.000	1.000
Total Annual Cost (2019 Dollars - Maui)	**($/yr)**	**$727,535**	**$727,535**	**$727,535**	**$727,535**

Total capital investment (1990 dollars) = 4744 x (MMBtu/hr) + 368162 Equation 1

Total Annual Cost (1990 dollars) = 1522.5 x (MMBtu/hr) + 142643 Equation 2

Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] CRF = 0.05

Where:

I = Interest Rate (3.25% interest)
a = Equipment life (30 yrs)

EPA Ref Capital Recovery Factor (CRF) = [I x (1+i)^a]/[(1+i)^a - 1] EPA Ref CRF = 0.13

Where:

I = Interest Rate (10% interest)
a = Equipment life (15 yrs)

Source: *Assessment of Non-EGU NO $_X$ Emission Controls, Cost of Controls, and Time for Compliance* , Technical Support Document (TSD) for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, November 2015

[A] The Maui construction cost multiplier is based on cost of construction geographical multipliers from the *RSMeans Mechanical Cost Data 2016 to account for factors unique to Maui s location plus an additional factor to account for additional Hawaiian Electric loadings and overhead.*

Life	Interest %
30	3.25

Life	Interest %
15	10

DOH-CAB Changed Spreadsheet

Appendix Table D-1. Ultra-Low Sulfur Diesel (ULSD) Import Cost

Description	Value	Units
Platts 2018 Price [A]	86.75	$/BBL
2019 Inflation	1.5	%
Platts 2019 Price	88.05	$/BBL
Freight [B]	5.51	$/BBL
Terminalling Fee [B]	2.00	$/BBL
Total ULSD Import Cost [C]	**95.56**	**$/BBL**
	2.28	**$/Gal**

[A] S&P Global Platts - Oilgram Price Report, listed price is Singapore spot price for Gasoil 10 ppm which is comparable to ULSD. (https://www.spglobal.com/platts/plattscontent/_assets/_files/en/productsservices/market-reports/oilgram-proce-report-060818.pdf)

[B] Hawaiian Electric Fuels Division Estimate.

[C] Platts 2019 spot price plus freight and terminalling fees.

Appendix Table D-2. Diesel (0.4% Maximum Sulfur) Import Cost

Description	Value	Units
Platts 2018 Price [A]	85.12	$/BBL
2019 Inflation	1.5	%
Platts 2019 Price	86.40	$/BBL
Freight [B]	5.51	$/BBL
Terminalling Fee [B]	2.00	$/BBL
Total ULSD Import Cost [C]	**93.91**	**$/BBL**
	2.24	**$/Gal**

[A] S&P Global Platts - Oilgram Price Report, listed price is Singapore spot price for Gasoil 0.25% S which is comparable to the current diesel supply.

(https://www.spglobal.com/platts/plattscontent/_assets/_files/en/productsservices/market-reports/oilgram-proce-report-060818.pdf)

[B] Hawaiian Electric Fuels Division Estimate.

[C] Platts 2019 spot price plus freight and terminalling fees.