Technical Appendix: Climate Pollution Reduction by Weatherization and Improved Energy Efficiency of University of Alaska Buildings and Assets

Methods and Assumptions Used in Estimating the Reduction in CO_2 Emissions

More detail for the CO_2 emissions reduction calculations is provided in the Technical Appendix spreadsheet that has been uploaded as part of the application package. The first tab of the spreadsheet shows how annual emission reductions were extended to the 5-year and 25-year time periods. The calculation method and underlying assumptions are briefly summarized here for each Measure.

Measure 1. Seward Marine Center Seawater Heat Pump. The annual reduction in fuel oil consumption was estimated from the proportional reduction (about 79%) achieved by a neighboring facility, the Alaska SeaLife Center (ASLC), which installed a similar seawater heat pump system in 2012. UAF was a research partner for that installation. The fuel oil consumption reduction was converted to CO_2 emission reduction using a standard factor of 10.19 kg of CO_2 per gallon.[1] An underlying assumption is that the Hood Laboratory at the Seward Marine Center would achieve the same proportional savings as the ASLC. The ASLC is a much larger and more complex facility than the Hood Laboratory, but as long as the heat pump is sized appropriately, that should mean that the Hood Laboratory installation would yield better results. In addition, heat pumps have improved significantly in the last decade.[2] Therefore, the estimate of GHG emission reduction is conservative.

Measure 2. Replace Inefficient Ultra Low Temperature (ULT) Freezers. UAF's standing stock of ULT freezers has been purchased over decades, almost entirely from grant and contract funds. The State of Alaska rarely provides funding for either research or educational equipment, except in a few areas that have captured public interest, such as drones. The power consumption of a representative selection of the existing freezers was measured during 2020.[3] The measured per unit consumption was multiplied times the number of freezers to be replaced (about 38) to obtain the total baseline consumption. Manufacturer specifications (average of two) of modern ULT freezer power consumption multiplied by 38 (the minimum number of new freezers) gave the predicted power consumption after replacement. The power use reduction estimate was multiplied by 2.3 lbs. of CO_2 per KWh, the EIA value for a coal-fired power plant. However, this is conservative since the UAF Power Plant ratio measured in 2023 is about 3.0 lbs. of CO2 per kWh.[4] Overall, this estimate of CO_2 emissions reduction is straightforward and accurate except for a probable ca. 25% underestimate. Measure 2 is the most cost effective and easiest to implement of all of the Measures.

Measure 3. Pathways and Parking Lots LED Lighting Conversion. The lights operate for about 4200 hours per year; they are centrally controlled and metered. The wattage of current lamps was taken from manufacturer specifications, and the resulting power consumption was compared with metering data as a check. The power consumption of new lights was from manufacturer specifications. The total difference for 422 lights was multiplied by 2.3 lbs. of CO_2 per KWh, the EIA value for a coal-fired power

[1] Calculated using the EIA crbon dioxide coefficient for diesel and home heating fuel, 10.19 kg CO_2 per gallon, and the net heating value of diesel fuel, 128,450 Btu/gallon.
https://www.eia.gov/environment/emissions/co2_vol_mass.php

[2] By Crownhart, Casey (2023) Everything you need to know about the wild world of heat pumps. *MIT Technology Review.* February 14, 2023. https://www.technologyreview.com/2023/02/14/1068582/everything-you-need-to-know-about-heat-pumps/

[3] Results were reported in "Research and Academic Sample Preservation", which has been uploaded as an optional appendix to this application.

[4] The UAF power plant provides not only electricity, but also co-generated steam used for heating and cooling.

plant.[5] The UAF power plant actuals were about 3.0 lb CO_2 per kWh in 2023, so using the EIA value is conservative. In summary, this calculation is also straightforward and accurate.

Measure 4: Kodiak Laboratory Ventilation Upgrade. The current fuel oil consumption was based on actual use. The fuel oil energy consumption after the renovation was estimated by a design consultant (Bell Design Group),[6] based on the projected decrease in exhaust air, in a schematic design completed in 2010. The difference in fuel consumption per year and the EIA ratio 10.19 kg of CO_2 per gallon of fuel oil was used to calculate the CO_2 emission reduction.[1] The result should be accurate, although the behavior of a redesigned ventilation system is not as perfectly predictable as that of an LED light.

Measure 5. Kuskokwim Campus Lighting Conversion to LED and Motors Replacement. The energy savings was calculated based on the lighting renovations only, because information on the existing pumps and fans is not readily available. So, this is a conservative estimate. There are 800 T8 28 W tubes installed at present, consuming 224 kW hours per day for assumed use of 10 hours/day. They would be replaced with 10 W LED, consuming only 64 kWh/day assuming that automatic controls will reduce use to 8 h per day. The reduction in kWh was used to calculate CO_2 emission reduction using the EIA CO_2 emission/kWh for diesel engine generators, which are the source of Bethel power.[7] The CO_2 emission reduction calculation is an underestimate because of the omission of the motors. We note that the power consumption of the Kuskokwim Campus buildings is notably high and not fully explained by the lights, which is the reason that thorough investigation of the motors and other potential power sinks would occur if this application is funded.

Measure 6. Exterior Wall Replacements to Reduce Heat Loss. Steam consumption is metered for each building, and those data were used for baseline. Quantitative heat loss studies have not been done for the Bunnell, Patty, or Eielson Buildings, because until this grant opportunity arose, they did not appear necessary; the perimeter heat loss is obvious and there is no remedy other than exterior wall replacement. Most (about 65%) of the heat loss from a typical, modern UAF building is due to ventilation, which must meet code requirements. This varies somewhat among buidings of different types. Science, engineering, and art buildings have higher ventilation requirements due to hazardous materials. Neither Patty nor Eielson Buildings are in that category, but Bunnell has a legacy ventilation system from when it housed the Biology Department more than a decade ago.

Since the modern buildings are much better insulated and have double or triple pane windows, assuming only 35% of total heat loss through the perimeter for the older buildings is very conservative. Further, the envelope heat loss reduction is expected to be better than 50%, based on the excellent

[5] ***Calculated using the EIA table "U.S. electricity net generation and resulting CO2 emissions by fuel in 2022", which shows 2.3 pounds (1.04 kg) of CO2 emitted per kWh generated from coal. https://www.eia.gov/tools/faqs/faq.php?id=74&t=11

[6] "Kodiak FITC Boiler Conversion Analysis" was uploaded as an optional appendix to this application. UA acknowledges that installing an electric heating system in addition to the ventilation changes would add substantially to the GHG emission reduction, since Kodiak power is hydroelectric, but the operating cost is uneconomic at this time.

[7] ***Calculated using the EIA table "U.S. electricity net generation and resulting CO2 emissions by fuel in 2022", which shows 2.38 pounds (1.08 kg) of CO2 emitted per kWh generated from petroleum. https://www.eia.gov/tools/faqs/faq.php?id=74&t=11

performance of the Usibelli Building exterior walls, so this is also a conservative assumption.

The reduction in total steam consumption due to reduced air exchange through the envelope was estimated at 18% (35%X50%). The steam consumption reduction estimate was used to calculate the reduction in CO_2 emissions using the ratio 137 lbs. of CO_2 emitted per 1000 pounds of steam; that ratio was derived from measurements at the UAF CHP. While there are significant uncertainties in this emission reduction estimate, it is very unlikely that it is too high.

Measure 7: Rasmuson Hall Boiler Replacement. The AKWarm software[8] was used for the estimate. It examines only perimeter heat loss and ventilation heat loads. The manufacturer specifications of efficiency for the existing and replacement natural gas fired boilers were used. The AKWarm software uses heating degree days to project the amount of fuel consumed annually. To convert the difference in fuel consumption by the two boilers to GHG emission reduction, the ratio 117 lbs. of CO_2 produced per million BTU of natural gas consumed was used.[9]

Measure 8: Conoco Phillips Integrated Science Building Combined Heat and Power Plant. The reduction in Chugach Electric utility power consumption and increase in natural gas consumption was calculated by a microturbine project design consultant, CHP Technical Assistance Partnerships, in 2020.[10] They used two different models for their analysis: the US DOE CHP screening tool, and the Washington State University Energy Program CHPSat Tool. The two models gave comparable results, which the consultant noted as supporting the reliability of the results. Chugach Electric Association, Inc., the cooperative that supplies power to UAA, uses mainly natural gas to generate power but has about 19% renewable sources, mostly hydroelectric. The consultant that did the calculation of CO_2 emissions (RSA Engineering, Inc.) took the renewable sources into consideration. The baseline was actual power and natural gas consumption by the facility for four years prior. The net energy savings was converted to the CO_2 emission reduction using the ratio 117 lbs. CO_2/MMBtu.

[8] https://www.analysisnorth.com/AkWarm/AkWarm2downloadPublic.html

[9] https://www.eia.gov/energyexplained/natural-gas/natural-gas-and-the-environment.php

[10] CHP Technical Assistance Partnerships Northwest Report, included in the optional appendices as an addendum to *The information presented in the first five columns of the table is from a contractor report, "University of Alaska Anchorage, ConocoPhillips Integrated Science Building, Combined Heat and Power Upgrades, Greenhouse Gas Emissions Reduction Analysis." This document was uploaded as an optional attachment in the "other attachments" section of the application package.