

Alaska CIP Energy Efficiency Major Maintenance Items (Alaska Department of Education and Early Development, DEED)

Reference Case

The building stock data for the public buildings was taken from a dataset with 22 buildings with information about the building types, the year-of-construction, heating-fuel, and square-footage. By cleaning up and mapping to candidate buildings (discussed further below) and align the type of each building with something that's addressable in our dataset of U.S. buildings, we searched for keywords in the existing descriptions. For example, if the unstructured type had the word "Shed" or "Storage", then we assigned those buildings the "Warehouse" type, whenever applicable.

The other required parameters to index our database of building properties are square footage, year-of-construction, heating-fuel, and zip-code. Most of the buildings in these datasets had zip codes. The resulting stock of public buildings contains approximately 22 buildings. Once this dataset was properly cleaned, a model was created for each building using the information on-hand. The models are constructed in EnergyPlus, the industry standard building energy simulation tool, using the automatic generation capability of the Constellation Navigator software. Because only the 5 main variables were available, all other energy-relevant building data was taken from the most applicable of the approximately 1,000 representative building energy models developed by NREL, PNNL, and DoE. The most applicable data source for each building was determined by comparing the year of construction, zip code, building type, and heating fuel (as assumed from other fuels in the building).

It is planned to calibrate the reference case to measure historical utility fuel delivery quantities at the state level. This was accomplished by joining these commercial public sector buildings with the AK PARCEL AND LOT set (discussed below) to ensure all commercial buildings in the state are represented. This step ensures that models at the building level are not over- or under-estimating any fuel usage, and it also helps us refine the assumptions made for heating fuel at the building level.

Measure-specific implementation assumptions

For envelope changes, levels of insulation and sealing as well as window upgrades were modeled. Additionally, wherever meaningful, the installation of VRF, commercial heat pumps and LED lighting, alongside variable speed drives on pumps and fans. In certain buildings, HVAC Heat Recovery and CHP installations were modeled, whereas in others Condensing Boilers and Ground-source heat pumps (GSHP) were modeled in. See energy use and emission details in the support file.

The efficiency upgrades in this set of measures include the replacement of all non-LED lighting fixtures with LED fixtures, the addition of wall and roof insulation, and air-sealing of the envelope. In the implementation of the insulation upgrade, it's assumed that the space exists to install the levels of insulation modelled, which in some cases requires the extension of the depth of the walls. The amount of fixtures that are currently LED is determined based on the year of construction or last renovation of the building. For buildings which have been more recently

renovated, it's assumed that they have more LED's installed, with the converse effect also assumed.

A full audit is also planned such that other tertiary measures could be implemented, wherever applicable. For example, the audit can lead to the identification of low-cost savings opportunities not otherwise modelled, including boiler system tune-up, such as remove scaling or deposits, other maintenance; outdoor air system tune-up such as the identification of any leakage; any lighting controls measures or hot water supply temperature resets; supply air temperature resets and space air temperature setpoint setbacks, as well as adjusting demand-controlled ventilation air or tuning exhaust fan schedules.

The models show competing ECM emission reductions, which will be finalized upon the audit. Specifically, for these mutually exclusive ECMs, a baseline facility can be upgraded with either VRF, Heat pumps, as explained above; or a CHP, GSHP or condensing boiler - not all. As a result, the emission reductions for these set of ECMs are not summed up, but the mean is assumed. For the Condensing Boiler ECM (#11), the measure would replace the existing heating system with a condensing natural gas boiler. Implement a hot water supply temperature reset strategy to most effectively operate the boiler. For CHP (#12), the measure would replace existing heating system with a natural gas Microturbine, optimized for overall efficiency. Operate the Microturbine to meet all heating loads in the facility, using the generated electricity to run electric loads in the building. In times when excess electricity is generated, it could potentially sell back to the electric utility or stored. Finally, for GSHP (#13) the measure would replace the existing heating system, and cooling system if applicable, to a ground-source heat pump. The size of the ground loop and heat pump will be scaled to meet the entire heating load of the facility upon further analyses. For facilities that current has a boiler, then the heat pump installed is a water-to-water heat pump, otherwise, it is a water-to-air heat pump. Therefore, no changes to the hot water or air distribution system are required. Beyond these ECMs, the others are modeled separately, and can be implemented at the site together, but may show overall decreased performance when implemented together - due to overlapping or counteracting gains.

Measure-specific activity data

Approximately 22 of the public buildings will be receiving energy efficiency upgrades. For example, E1.1.1 and E1.8. External post insulation is added to the exterior walls and roof to reach the U-value specified by ASHRAE 189 2020 (p141) for the climate zone. A secondary measure will model the envelope air tightness is reduced to 0.25 cfm/sf as specified by ASHRAE 198 2020 p88, section 10.6. Additionally, E6.5.4 and E6.3, replacing all lighting with lighting power density which meets the 2020 ASHRAE 189 LPD levels.

Models/Tools used:

- Constellation Navigator automatic energy model processing: used to create reference case models, upgrade-scenario models, and compare them (shown in appendix)
- DoE Commercial Reference Building Models: used as a source of data for building characteristics that do not exist in the building-specific datasets, and estimated EUI by end-use

GHG Reduction Estimate Method:

The difference between the reference (base) case and the modeled changes in energy due to the modeled adoption of measures discussed above, is the activity data being used to estimate the reduction in GHG. For example, after buildings are simulated using the tools and assumptions above, the estimated reduction or increase in different types of fuels, such as natural gas, coal, liquid fuels or electricity, is converted from MMBTU or its energy equivalents, into MT CO₂e using the corresponding emission factors for that fuel type, across the constituent CO₂, CH₄ and N₂O. Next, EPA's 2022 GWP values are used to convert to each MT per GHG type into aggregated annual MT CO₂e – using 1 for CO₂, 298 for N₂O and 25 for CH₄. Whenever appropriate, the emission factors of electricity, is matched using the community the buildings are in, and either the PCE based emission factors, or the grid-rates for the sub-region.

Source: https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf

GHG Reduction Estimate Assumptions: The quantification does not assume any impacts of “joint strategies” – that is, the simultaneous impact of multiple projects at a single location. In other words, if a project analyzes the reduction of grid emissions based on upstream integration of renewable energy, the new emission factors of electricity are not being used to measure the impact of electrification or efficiency of end-use equipment, as stated above. Instead, the reference emission factors will be used. Similarly, if competing efficiency projects are modeled such that they are not additive, but are substitutes of each other, the extent of overlap is not being modeled or predicted. Additionally, the baseline models assume annualized load profiles – and actual building performance may differ, such as from partial usage or occupancy, etc. Lastly, there are no weather normalizations done on either the activity of the reference scenario or modeled measures.

There are instances where, given the usage profiles, equipment assumptions and climate zone, certain ECMs can increase emissions. For example, in the case of lighting, for inefficient lighting, most of the energy lost is lost as heat into the space. Therefore, when these fixtures are replaced, the heating system has to work harder. In climates like Alaska, this effect is larger because most of the time, the HVAC system is heating. However, heat lost from lighting fixtures is not efficiently distributed and not all energy lost goes into the space, therefore almost all the time, it will save more electric energy than you increase heating energy. Separately, for other end-use ECMs, such as with VRF, which is a fuel-switching measure similar to heat pumps, while it is a more efficient way of heating, but with poor emissions factors, it's possible that it increases emissions. Next, for windows, there could sometimes be a small cooling energy increase - largely because the measure is for windows that allow a lot of solar heat gain, which is very helpful in heating periods. The buildings which show this effect the most have warmer climates, building types with more heat gain - leading to more cooling energy, and more window area. This effect should be completely overshadowed by the additional heating benefits from having a high solar heat gain coefficient.

GHG Emission Reduction Calculations: See attached technical appendix with linked Spreadsheet.