BUUF Non-GHG HVAC project, 6/25/23

Updated 10/11/23 with information from Debbie Johnson's 9/9/23 HVAC status report

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Summary

72% of BUUF"s carbon footprint comes from using Natural Gas HVAC units. The units are nearing the end of the life span or have exceeded it and several are not working. Replacing them with non greenhouse gas emitting units and getting 100% of our electricity from renewable sources could reduce BUUF's footprint to meet or exceed the 2030 goal of a 45% reduction that is needed to avoid climate disaster.

THe BUUF Board commissioned a study with the goal of finding an HVAC system that would reduce BUUF's carbon footprint, increase energy efficiency, improve ease of control and building comfort while allowing a phased implementation. The study presented three options, but none seem feasible. One, a combination of natural gas and heat pumps, doesn't appear to meet our GHG reduction goals, the second, an all electric system, requires expensive and time-consuming electric service upgrades and the third is too expensive.

A fourth option suggested separate HVAC units to the offices, kitchen and nursery. These units are not part of the original system and would reduce the load on the replacement system and have a zero carbon footprint.

The BUUF Board is considering Interim repairs to the units of the existing HVAC system, to give us time to continue looking for a workable solution. They also commissioned a study of the building's envelope to determine the heating requirements during weather extremes. This will help determine the natural gas usage of the first option. The study will also look at electricity usage to see how it compares with the capacity of our existing electric service.

Background

BUUF has 8 Natural Gas burning HVAC units, four in the Sanctuary, and 2 in each wing. In March 2023 we were alerted that three of the units were not working. This was considered an opportunity to reduce BUUF's carbon footprint by replacing some or all of the units with systems that do not emit greenhouse gasses (GHG).

BUUF's Carbon Footprint

The carbon footprint of BUUF's building and landscaping is 32.26 metric tons (mt) of CO2e/year. 72% of the footprint is the 23.8 mt of CO2e from natural gas heating. The 2030 reduction goal is 14.97 mt/year.

If we switch to 100% clean electricity and replace our natural gas HVAC system with an electric equivalent, the footprint will be 7 mt/yr of CO2e. Figure 1 shows how BUUF carbon footprint can be reduced as portions of the HVAC system are replaced. Please see *BUUF Carbon Footprint* for more in depth information about the carbon footprints.

The BUUF Board authorized the switch to 100% clean electricity which reduced the footprint to 30.77 mt/yr and commissioned Musgrove Engineering to investigate alternatives to natural gas HVAC systems that meet these four goals:

1. Reduce carbon footprint and eliminate use of fossil fuels.
2. Increase energy efficiency.
3. Increase individual space comfort and control.
4. Phased approach to replace equipment over time.

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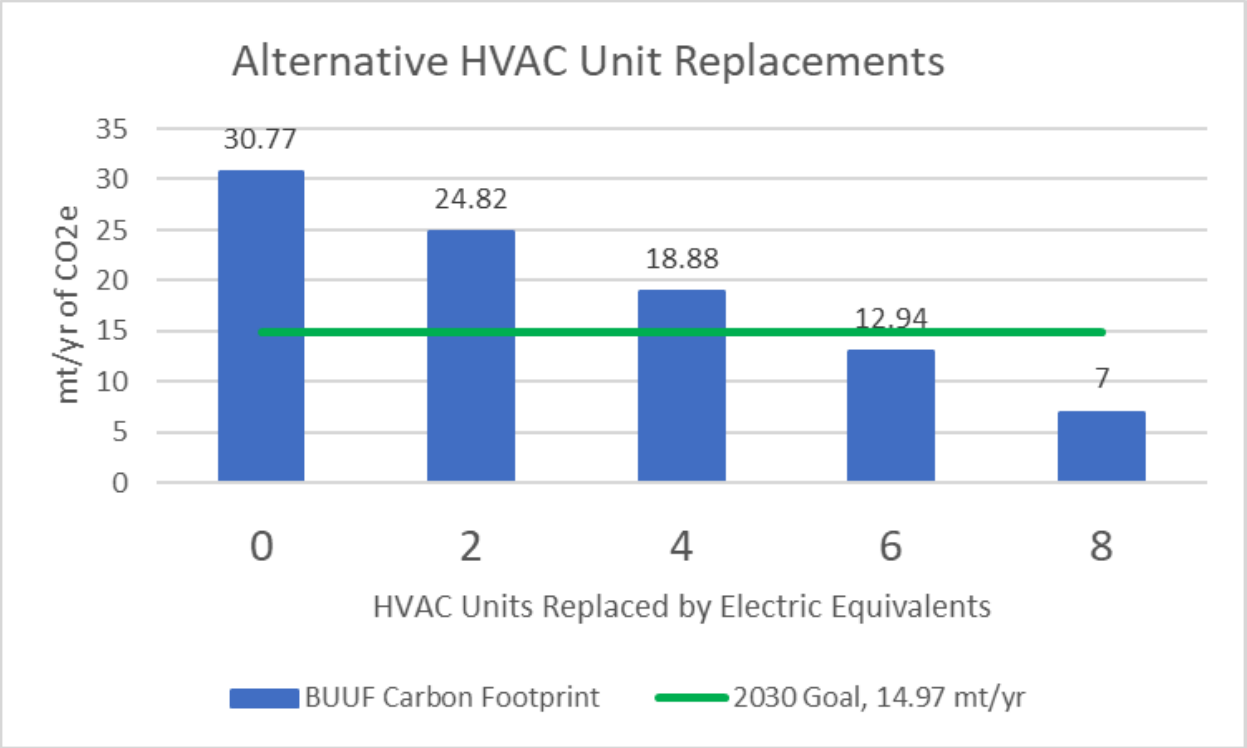

Figure 1. Alternative Replacement of HVAC Units with non-greenhouse gas emitting equivalents

Results of the HVAC replacement study

Musgrove Engineering conducted the study of the BUUF's building and HVAC systems and released their report May 26, 2023. The report contains the following topics:

- Existing conditions, discussing the condition the building and its HVAC system
- Options for HVAC systems
    - #1 Gas fan coil units and outdoor heat pumps
    - #2 Electric fan coil units and outdoor heat pumps
    - #3 Variable Fluid Flow (VRF) with heat recovery and DOAS systems
    - #4 Add multi-zone heat pumps systems to other areas
- Outside Air
- HVAC controls
- Installation costs and life cycle costs comparisons
- Recommendations
- Utility Incentives

The following is a summary of the report, please see *Boise Unitarian Universalist Fellowship HVAC Upgrade Study* for the entire report.

Existing Conditions

BUUF's building envelope

The windows are original to the building, which was built in 1997. "Some windows include adjustable vertical blinds to control heat losses and gains, however, most windows do not. Some window seals have visible cracks and fatigue which is typical of the age. Most exterior doors appeared to have well-sealed frames with door sweeps."

HVAC Systems

There are eight furnaces, four in the sanctuary and 2 in each wing. Each furnace includes an outdoor condensing unit for the air conditioning . The four furnaces in the sanctuary are 27 years old and beyond their recommended lifespan of 18 years and their condensing units are also beyond their recommended lifespan. Three of the four furnaces in the wings are 18 years old with a useful lifespan of 19 years and all four condensing units are near the end of their lifespan with insulation on their refrigerant lines cracked and failing.

Outside Air Systems

The systems to provide outside air both to the furnaces and for energy conservation needs repair and upsizing to meet code required specifications.

Options for replacing/upgrading the HVAC system

The goals of the Boise Unitarian Universalist Fellowship for upgrading the existing system are as follows:

1) Reduce carbon footprint and eliminate use of fossil fuels.
2) Increase energy efficiency.
3) Increase individual space comfort and control.
4) Phased approach to replace equipment over time.

To meet these goals Musgrove Engineering outlined four options to replace the existing HVAC systems and compare how they will meet these goals, compare installation costs, and compare operational costs.

Option #1 - Gas furnace/heat pump condensing units.

This option uses heat pump outdoor units with backup natural gas heating. in Boise's there would be a 25% reduction in heating capacity below 11℉ and further reductions at colder temperature.

This option would not meet our carbon footprint reduction goals because the gas furnace would operate when the heat pump is not sufficient at colder temperature or when the building usage requirements switch from used/cold to used/warm. Subsequent discussions with the firm

suggest that the gas furnace could turn on at 30 ℉ and so exceed the carbon footprint goal for the building,

Further study is needed to determine the load calculation of the building, that is, the measure of energy needed to be added or removed from a space by the HVAC system to provide the desired level of comfort within a space. This takes account of the surface area exposed to the outside (walls, ceiling) and the insulation value, including windows and doors. It is important we know how many Btu are escaping through the walls and ceiling when it's really cold outside to know how much we need from the heating equipment. Additionally, it would be helpful to have a better handle on our current electrical load compared to the building capacity to help estimate how much we have available for the new system.

Concerns exist and further study is required, but does not meet requirements as described.

Option #2 - Electric fan coil unit/heat pump condensing units.

The existing gas furnaces can be replaced with fan coil units that include a heat pump heating/cooling coil, a backup electric heating coil, and individual thermostats. By switching to electric heat these units will completely eliminate natural gas usage in the Building.

It is important to note that the backup electric heating coils would create a significant additional electrical load on the building electrical service that was not previously planned for. This may require significant modifications

There are a couple of limitations from Idaho Power for us to switch to electric furnaces. The distribution facilities (transformer and building feed from Idaho Power) would need to be replaced with facilities with greater electric capacity. The cost is $70,000 to $80,000, plus Idaho Power has a supply chain backlog for transformers and they are telling customers to expect three years before the upgrades could be done.

Further study underway due to high infrastructure upgrade costs.

Option #3 - VRF systems with Heat Recovery and Dedicated Outdoor Air Systems

The existing furnace and air conditioner systems could be replaced with a variable refrigerant flow (VRF) system that includes heat recovery. VRF systems use refrigerant as a cooling and heating medium. The refrigerant is conditioned by a single larger outdoor unit, and heating/ cooling is distributed through indoor fan coil units.

A VRF heat recovery system is also much more versatile and provides precise temperature control by allowing the system to heat and cool separate zones separately. The furnaces could be replaced with ducted fan coil units and the outdoor units could be combined to fewer larger

common outdoor heat pump units. VRF systems with heat recovery offer very high heating and cooling efficiencies but typically come with a few drawbacks.

This option is too expensive for consideration.

Option #4 - Add multi-zone mini-split heat pump systems to offices, nursery, and kitchen.

To increase occupant comfort and control in areas such as the offices, the nursery, and the kitchen multi-zone ductless split systems could be added with individual thermostats. The office areas could include individual ductless fan coil units and thermostats for each space which are tied to a single outdoor heat pump unit.

This would add heat pump systems that would decrease the load on the eight unit HVAC systems being discussed. There are limitations to the multi-zone recommendation, the units could conditioning only one zone at a time. Also, new venting to the required, however this work is required in any case to come up to code.

Considerations and plans moving forward

Please see the President's Report, June 2023 and the slides from the June 2023 BUUF Board's discussion of HVAC upgrades.

Option #1, a gas backed heat pump almost works, but there are concerns that the performance of the system at low temperatures and high demand will exceed our carbon footprint goals. Option #2 could mean very expensive and time-consuming electrical infrastructure upgrades.

Immediate Plan

BUUF members Debbie Johnson and Bob Smith worked with Idaho Power to determine the if BUUF's current electrical Infrastructure could support using Option #2, a combination of electric furnaces and heat pumps.

Long term considerations

For a project of this size and importance to the building comfort and operation, BUUF President, Debbie Johnson recommends we go the normal construction route, having the engineer develop specifications and bid documents, solicit bids from contractors, and have the engineer check the completed installation for deficiencies and punch list items. The cost estimates for these services are identified in Appendix B as MEP design fees for each of the options. The estimated costs for MEP design fees are shown as: Option #2 $19,100, Option #4 $ $9,800, and Outside Air $6,700.

- Option #1, multi-speed gas furnaces & high-efficient Heat pumps $277,970
- Option #4, ductless split systems for offices, nursery and kitchen $ 78,200
- Modify Outside air system $ 64,400
- MEP, professional specification, bid prep, and construction review $ 35,600

Short term considerations (Debbie Johnson)

Given the magnitude of needed funding, let's look at how we might be able to do minimal HVAC work in the near term to get by and begin funding efforts and then construction in a year, year-and-a-half, or maybe two years.

The study was a broad brush of overall system feasibility, not detailed enough for final equipment purchase decisions. But I think that can happen pretty quickly and not cause any comfort concerns. We'll want the engineer's specifications before replacing any of the three failed furnaces.

I think we can repair one of the sanctuary units for heating for around $1,200, the one with the failed blower motor. This would enable all four sanctuary units to provide cooling and three of the four to provide heating next winter.

The south classrooms unit provides air conditioning, but not heating. Working with the engineer and knowing what the final whole system design will be, we could replace the one classroom failed furnace with a variable-speed furnace that will be compatible with the subsequently installed heat pump. This might cost $13,000-$15,000, plus maybe $3,000 to $5,000 engineering fees.

I think we could spend a little over $20,000 this fall before winter and have the building comfortable for another year or two while we actively plan for construction and funding.