Inclination Engineering

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Inclination Engineering

Elevating Building Performance

MEP Equipment Replacement Plan

Rosedale Gardens Presbyterian Church

November 29, 2023

A Phased Plan to Update Your Building's Mechanical and Electrical Systems

EXISTING BUILDING SYSTEMS OVERVIEW

Background on the existing equipment and constraints

EQUIPMENT USEFUL LIFE REMAINING

Evaluating Replacement Timing

The building's existing mechanical equipment has a wide range of ages. The adjacent charts shows the equipment age plotted over the equipment's expected useful life range. For example, a rooftop unit has an expected useful life of 15-20 years. You can see that HVAC-1, at 17 years old, just passed from the gray zone to the red.

IMMEDIATE NEEDS

The timing of when this plan's tasks should be completed was based on when equipment was likely to fail based on reaching the end of its expected useful life. The second chart captures a longer timeline, out to 70 years and shows several pieces of equipment that are far beyond their expected useful lifespans.

Replacing the boilers should be the top priority. They boilers are well beyond their expected useful life and critical issues were discovered in boiler 1 during fall startup.

EQUIPMENT TO REMAIN

The youth hall furnace (FAF-1), chapel and classroom split systems (ACs), and rooftop unit HVAC-2 have the more than ten years left in their expected useful lives. This equipment is expected to remain and was not included in this equipment replacement plan.

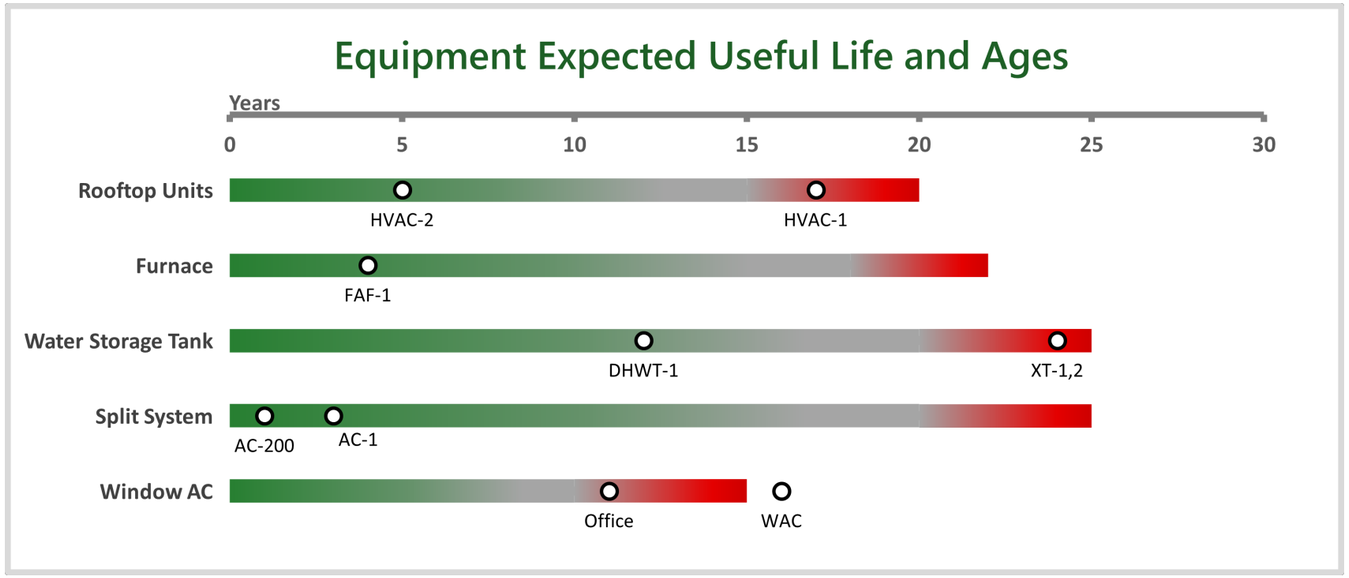
CASE-BY-CASE REPLACEMENT OR A COMBINED PROJECT

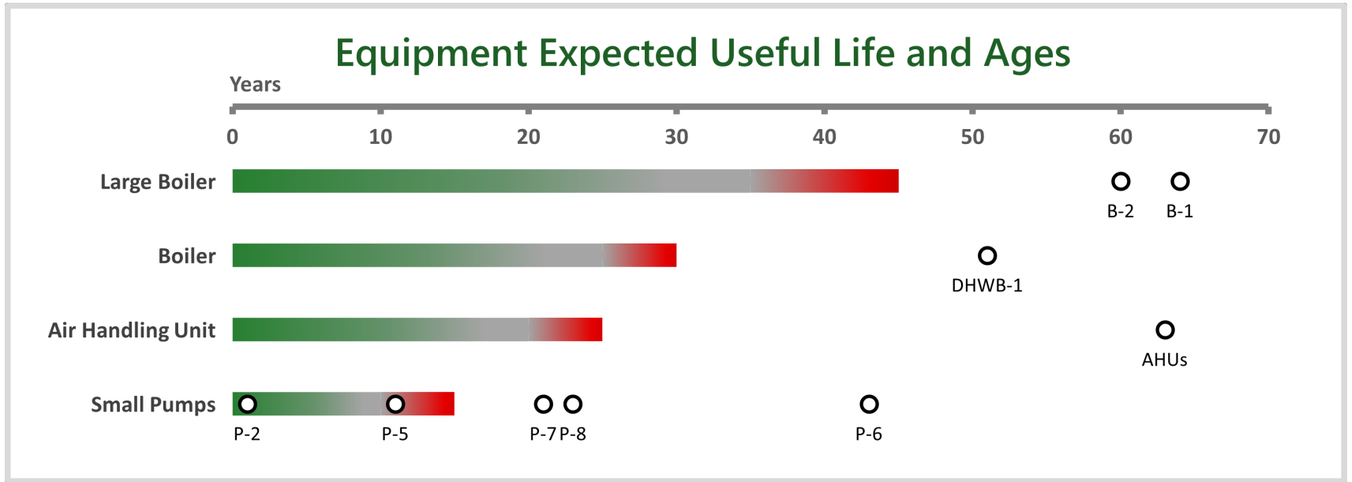
Most of the other tasks recommended in this replacement plan deal with replacing the equipment that is near the end of its expected useful life or addressing existing deficiencies in the mechanical and electrical systems. These tasks do not need to be addressed as immediately as the boilers, but should still be completed within the next five years.

The older Sanctuary rooftop unit (HVAC-1) is within the range for the end of its expected useful life. This unit provides ventilation and cooling to the Sanctuary. Should it fail, services could continue with the remaining HVAC-2, however the space may be a bit warm in the summer. Similarly, the window air conditioners are at or past the end of their expected useful lives. They could be upgraded one at a time as they fail.

An alternative approach would be to combine many of the tasks in this plan with the boiler replacement project and complete them over the next two years. Given the long lead times to schedule a contractor and especially to order some equipment, this proactive approach will avoid dealing with uncomfortable space conditions while waiting for equipment to be replaced. A combined project can also reduce the total costs by making it more of an attractive project for bidding contractors. A combined project also reduces administrative burdens and mobilization costs that would be associated with multiple small projects. Combining the project would also provide more options for financing.

Most of the tasks on the timeline on the following page show a completion range of 3-5 years. This is because the projects could be combined with the boiler replacement or could be spaced out and completed as money is raised or as equipment fails.





Several of the existing pieces of mechanical equipment are approaching the end of or have exceeded their expected useful lives. Chart was made in September of 2023.

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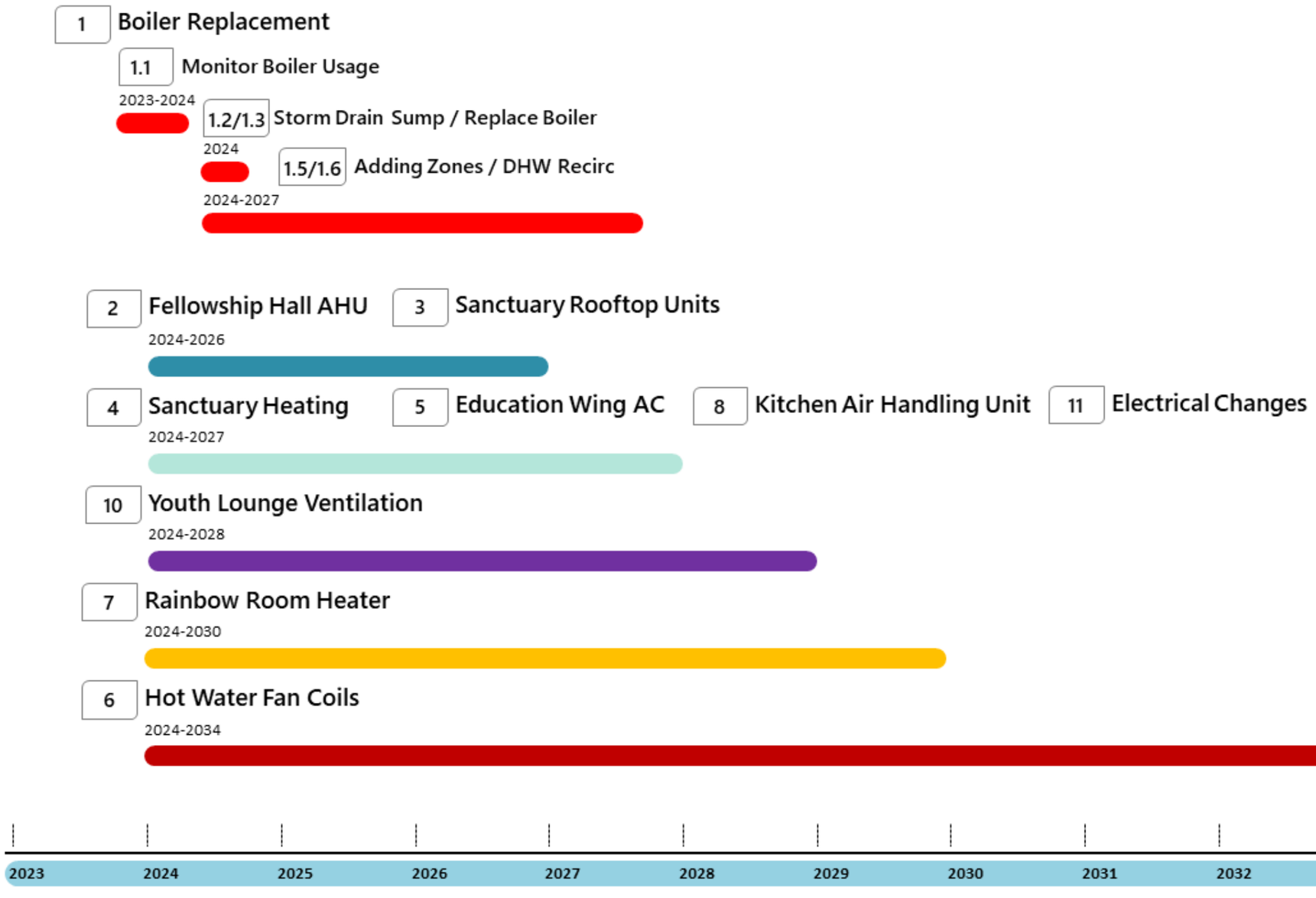
EQUIPMENT REPLACEMENT TIMELINE

Rosedale Gardens Presbyterian Church

9601 Hubbard St., Livonia, MI



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1 – BOILER REPLACEMENT

Improve reliability, increase operating efficiency, and consolidate heaters

TIMING
2023-2027

PROBABLE COST
$270,000

SUBTASKS INLCUDED

1.1 Monitor Hot Water Demand
1.2 Storm Drain Sump
1.3 Replace Boilers
1.4 Boiler Controls
1.5 Adding Zones
1.6 Domestic Hot Water Recirculation

GOALS

- Improve the reliability of the church's heating system by replacing 60+ year old boilers.
- Reduce utility bills by using more efficient condensing boilers and hot water reset controls.
- Improve domestic hot water performance with a code compliant recirculation system, keeping pipe mains hot and reducing wait time for hot water.
- Consolidate from 3 boilers to 2.

TIMING

- Winter 2023—1.1 Monitor Boiler Usage
- Spring 2024—Develop design documents, get permit
- Summer 2024 – 1.2 Storm Drain Sump, 1.3 Replace Boiler, & 1.4—Boiler Controls
- Summer 2024 or later—1.5 Adding Zones & 1.6 Domestic Hot Water Recirculation

Boilers lead times are currently 6 to 8 weeks. The project would be best done over the summer. Design and ordering should take place as early as possible to allow enough time to order the boilers and prep the install.

Tasks 1.4 and 1.5 could be done with the boiler replacement or done later.

COORDINATION

The boiler replacement project needs to be coordinated with tasks:

2 – Fellowship Hall AHU

9 – Controls

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SPACE HEATING BOILERS (B-1 & 2)

URGENCY OF REPLACEMENT

The main boilers (B-1&2) were installed during the construction of the Education Wing 60 years ago. They have exceeded their expected useful lives and Boiler 1 is barely operable. These boilers provide the majority of the heat used by the building. During all but the coldest weather, only one boiler is operating at a time. With boiler 1 down, the church will be able to continue operating using boiler 2. It is very possible that given their age, both boilers could fail and leave the church without heat. We strongly recommend this be the top equipment replacement priority.

CONTRACTOR ASSESSMENT

Mechanical contractors from Motor City Heating noted concerns when checking boiler 1 prior to fall start-up. The technician noted the firebrick is deteriorated inside and the metal orifices that the flames travel through are showing signs of melting. The boiler is also shooting spurts of flue gases back into the room from the connection point of the boiler to the flue. His recommendation is not to use boiler 1 and keep it as an emergency-only alternative.

DOMESTIC HOT WATER BOILER (DHWB-1)

EXISTING EQUIPMENT

The church's domestic hot water is primarily used for handwashing sinks and mop sinks. Infrequent, but high demand comes from the commercial kitchen's dishwasher and pots and pans sinks. Domestic water is heated by a small gas boiler and stored in an adjacent 119 gallon storage tank. The boiler (DHWB-1) activates when there is hot water demand and also to maintain the water temperature in the tank.

The boiler is 51 years old, has exceeded its useful life, and should be replaced soon.

CONSOLIDATING EQUIPMENT

The church needs a relatively small domestic water heater for the daily demands and thermal losses from the pipes and tank. The hot water system also needs a high capacity backup heater when dishes are washed in the kitchen. Inclination Engineering proposes to consolidate the domestic hot water and space heating boilers. An indirect water heater connected to the boilers would handle the typical daily uses and the new boilers would have plenty of backup capacity for periods of high demand. The new boilers will be provided with today's standard controls that can handle this process automatically. Even in the summer, when the boilers are off, one of them would be turned on when needed.

Utility Rebates

The replacement boilers will qualify for the following gas rebates from Consumers Energy:

Name	Number	Rebate Rate	Total Rebate	Notes
High-Efficiency HVAC Hydronic Boiler	HV304	$2.00/ kbtu/h	$4,000	
Optimized Boiler Plant	BA301	$0.40/kbtu/h	$800	Pre-Notification

Energy Savings

The increased boiler efficiency and controls are expected to reduce annual gas consumption 16%, saving $1,600 per year

1.1 – MONITOR BOILER USAGE

Determine appropriate replacement size to meet load

TIMING
Winter 2023

PROBABLE COST
Free

ROUGH SIZING ESTIMATE

The two existing boilers each have 2,010,000 btu/h gas inputs. At a typical efficiency of 80% this means each boiler's heat output is 1,608,000 btu/h. Currently, the boilers are run one at a time in all but the very coldest weather. From this we can estimate the building's hot water demand at 1.6 million btu/h.

New boilers will have controls to turn-down during low demand and to automatically fire up a second boiler during high demand. To maintain redundancy we recommend providing two new boilers, each sized for 60% of the total heating demand. The new boilers will be condensing boilers with efficiencies closer to 90%. This means the two, 2 million btu/h boilers would be replaced with two, 1 million btu/h boilers.

ADDED LOADS

The ventilation load to the Fellowship Hall on AHU-1 will likely increase when AHU-1 is replaced. See Task– 2. The boiler replacement should anticipate this additional future load.

Adding the domestic hot water to heat hot water system is not expected to increase the boiler size. The typical domestic hot water demand for the church is low. Large periods of demand are expected when the kitchen is in use. These will be short periods and the building has enough thermal mass to deal with short declines in the heating hot water supply.

MONITORING EXISTING BOILER USEAGE

A great way to validate an engineering analysis of the building's heating demand is to measure the existing heating demand during cool and cold weather. The heat demand, blower motor, or gas valve command can be recorded by data loggers as a proxy for the boiler heat output. Data should be recorded over at least a full week to capture various use conditions. Data should also be recorded in fall or spring cool weather and again in cold weather. These two data points can be used to extrapolate a curve down to the design coldest weather, 4°F.

Performance Engineering is a boiler manufacturer's rep in Livonia that would be willing to provide free boiler usage monitoring to nonprofits and houses of worship. Contact Alan Deal.

Alan Deal
(734) 793-0733
adeal@performanceengineering.com
https://www.performanceengineering.com

1.2 – STORM DRAIN SUMP

Provide access to clean storm drain lines

TIMING
Summer 2024
with Task 1.3

BUILDUP IN DRAIN

Plumbers hired by the church inspected the storm drain mains under the floor of Fellowship Hall. They observed a "large quantity of mineral deposits and debris in the storm line." The mineral deposits appeared to be mostly calcification. This likely resulted because the foundation drains are tied into the storm line. The plumbers were concerned that if they flushed this material downstream it would clog the trap where the storm line drains into the building's sanitary sewer pipe. This trap is located under the boiler room floor. The trap has two cleanouts in the boiler room floor, however the plumbers were concerned that the material would be too dense and if the trap clogged it would backup all the storm drains.

BOILER ROOM SUMP

The plumber suggested providing an accessible sump just upstream of the boiler room trap. Then they could flush the debris into the sump and remove it without clogging the trap. The trap is in the NW corner of the boiler room under the north end of B-1. The two cleanout covers are visible in the floor. Since the new boilers will have a smaller footprint, a sump could be installed if carefully coordinated with the boiler replacement in Task 1.3.

FELLOWSHIP HALL EXCAVATION

Since the existing boilers block access to the trap, the plumbers proposed to excavate down to the clogged pipe below Fellowship Hall, remove a section of pipe and clean the debris back to the opening before replacing the pipe and refilling the hole. The same issue may happen in another part of the buried storm drain and require similar work be done again. We suggest monitoring the know clog, installing a sump in summer 2024 with the boiler replacement, then flushing the debris.

SECOND OPINIONS

Plumbers Service, the plumbers who inspected the drain, do not install interior sump pits. We recommend immediately contacting additional companies for quotes and second opinions.

1 – BOILER REPLACEMENT

1.3 – REPLACE BOILER

Upgrading to condensing boilers

TIMING
SUMMER 2024

PROBABLE COST
$225,000

DEMOLITION

The boiler replacement must be completed within a summer and demolition should begin in early spring. The existing space heating boilers, piping connections, pumps, and expansion tanks will also be demolished. The domestic hot water storage tank may be demolished or reused if it can be incorporated economically into the new domestic water heating design. The domestic water boiler should be demolished after the new boilers are installed to limit the domestic hot water disruption.

The boiler gaskets, floor tiles, and pipe insulation elbows contain asbestos. The abatement must be integrated into the boiler room demolition. This is included in the probable cost above.

NEW BOILERS

Two new condensing boilers will be installed in the boiler room each sized for 60% of the expected building heating demand. This is estimated to be 1 million btu/h heat input for each. Refer to Task 1.1—Monitor Boiler Usage for more information on confirming the boiler sizing. New expansion tanks, air separators, and related piping and boiler accessories will be provided.

COMBUSTION AIR AND FLUE

The boilers will use room air for combustion. The existing air intake louver in the wall is likely oversized and should be replaced with an appropriately sized louver.

The flue gases from the condensing boilers will be cooler and wetter than the previous boilers. The boiler room's exterior wall, adjacent to the main rear entrance, is not a desirable spot for boiler exhaust. Instead, a stainless steel or polypropylene liner will be installed in the existing chimney. The liner will be resistant to the condensate from the flue gases. A drain at the bottom of the chimney will lead to a condensate neutralizer.

CIRCULATING PUMPS

In the existing heating hot water (HHW) system, each zone has a constant flow, circulating pump. The pumps in the boiler room will be replaced with two, parallel piped, variable speed pumps, each sized for 60% of the peak flow. Zone control valves will be used to control the flow of HHW to each zone. Ideally the zone control valves will be installed where each loop splits between first and ground floors instead of in the mechanical room. See Task 1.5– Adding Zones.

One existing pump in the boiler room circulates hot water through the sanctuary radiators in the choir loft, organ chase, and stairway. Four additional circulator pumps in the mechanical room across the hall pull off downstream of this pump. There is one for each of the three air handling units (AHUs) and one for the radiators in the Narthex. This tertiary pumping setup will remain in the interim. As AHUs are replaced or modified the pumps should be replaced with zone valves.

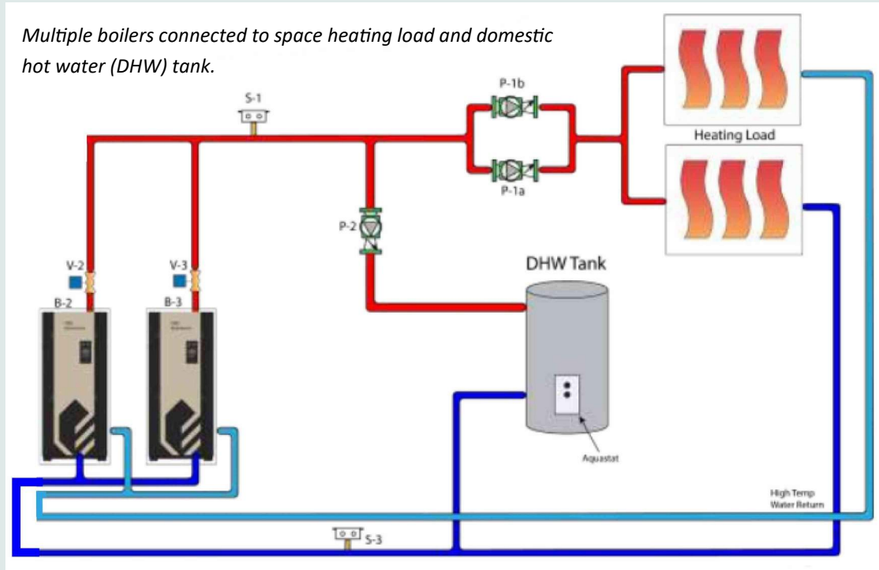
DOMESTIC HOT WATER HEAT EXCHANGER

The domestic hot water boiler and tank will be replaced with an indirect water heater tied into the boiler. The indirect water heater is a tank full of domestic water with a pipe coil inside it. Hot water from the boiler flows through the coil and heats, but does not mix with, the domestic hot water. A dedicated pump circulates heating hot water though the heater so that even in the summer, a boiler can turn on and heat the domestic hot water. During high demand, the boiler ramps up and can produce a lot of domestic hot water without an additional heater. A small electric heating element should be considered to manage stand-by losses.

ELECTRICAL

The existing boiler fans are currently fed from (2) 30 amp/3-pole switches in the existing switchboard, those will be reused for the (2) new 1-HP HHW pumps. There is also (2) 20-amp, 120-volt circuits for the boiler controls and (3) 20-amp, 120-volt circuits for the smaller boiler pumps located in the local panel RP-BR-1. (2) of the circuits will be re-used for the new boilers.

Multiple boilers connected to space heating load and domestic hot water (DHW) tank.



1.4 – BOILER CONTROLS

Getting the most out of condensing boilers

TIMING
SUMMER 2024

PROBABLE COST
$4,000

GOALS

- Run the boilers only when needed
- Start and stop the boilers automatically
- Maximize the efficiency of the condensing boilers

NEW BOILER CONTROLLER

A new boiler controller will be installed with the boilers. Instead of manually starting up the boilers in the fall, the new boilers will be available all year. They will automatically turn on when there is demand for hot water and turn up and down to match the demand. When the primary boiler approaches its full capacity, the controller will turn on the second boiler.

WARM WEATHER SHUTDOWN

The boiler controller will be connected to an outdoor temperature sensor and be programmed for warm weather shutdown. When the outside temperature is above the setpoint, 60°F for example, the boilers and pumps will shut down.

HOT WATER TEMPERATURE RESET

The boiler controller will be set up to reset the temperature of the heating hot water based on the outside temperature. In the coldest winter weather, 4°F, the heating hot water may need to be 140°F to 150°F to provide sufficient heat to the building. In more mild weather like 50°F, a lower temperature closer to 110°F would be enough. The boiler controller will ramp the outlet setpoint temperature between a maximum and minimum based on the outside temperature. The points are adjustable and some trial and error will be used to find the right setpoints.

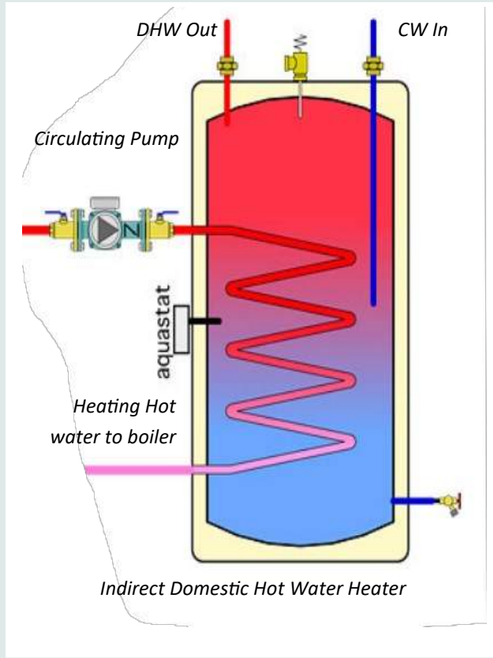
Lowering the heating hot water temperature in mild weather prevents overheating the spaces and boosts the efficiency of the boilers. Condensing boilers heat the inlet water with the flue gases. Cooler inlet water will condense vapor from the flue and extract more heat. Condensing boilers with 96% efficiency are rated with 80°F return water. The chart below shows how this efficiency changes as the return water temperature increases. The return water is typically 10-20°F cooler than the supply setpoint. 140°F supply water gives 120-130°F return. 110°F supply leads to a 90-100°F return, and much higher efficiencies.

LOWER TEMPERATURE RATED COILS

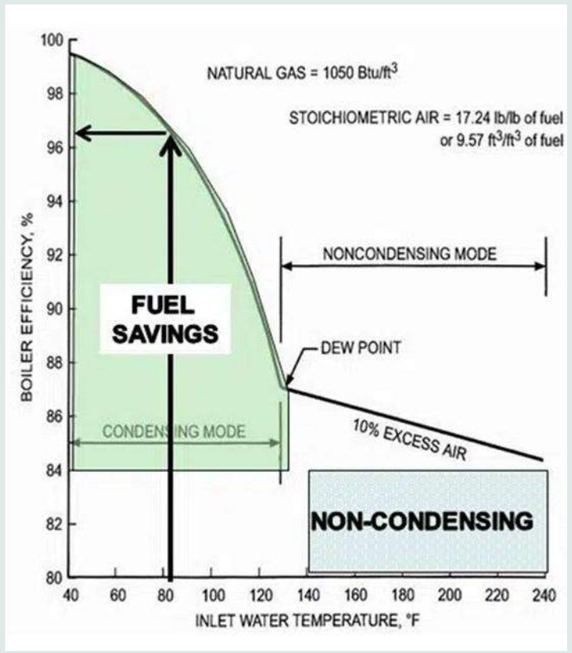
Air handling unit heating coils, baseboards, and unit heaters should be designed for a lower heating hot water temperature. Ideally this would be around 120°F. As coils are replaced over time, the boiler outlet temperature can be lowered.

DOMESTIC HOT WATER OVERRIDE

The boiler controller will override the warm weather shutdown and temperature reset to provide 140°F to the water heater. Once the water heater is satisfied, the previous programming resumes.



Indirect Domestic Hot Water Heater



1 – BOILER REPLACEMENT

1.5 – ADDING ZONES

Dividing zones to improve comfort and efficiency

TIMING
2024-2027

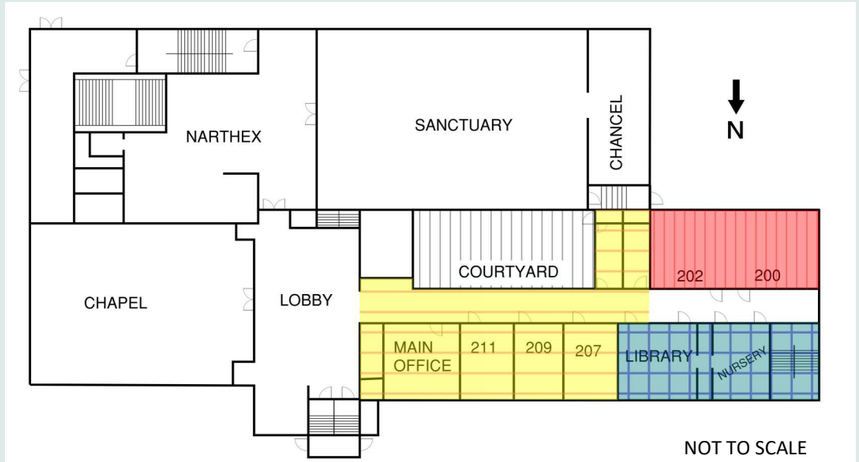
PROBABLE COST
$21,000

GOALS

- Allow for more control over the baseboard heating in the education wing
- Prepare for Task 5– Education Wing AC
- Increase comfort

EXISTING ZONING

The Education Wing heating is divided into three zones. Each zone has a thermostat to turn on a dedicated zone pump. The first floor plan at right shows the three zones. Each zone includes the ground floor spaces below those shown. These large zones lead to uneven heating. In order to make some rooms warm enough, others need to be overheated. We observed electric spaces heaters in the some rooms indicating the occupants were uncomfortable.



ADDING HOT WATER ZONES

In Task—5 packaged heat pumps would replace the window air conditioners in the rooms on the north side of the first floor. In the winter, each room will have control over the heat pump setpoint. The baseboard heating will be set to maintain a low minimum temperature of, for example, 62°F. Below a certain outside temperature, around 20°F, the heat pumps will not have enough capacity to maintain comfortable conditions. The baseboard will then kick in to serve as the backup heat.

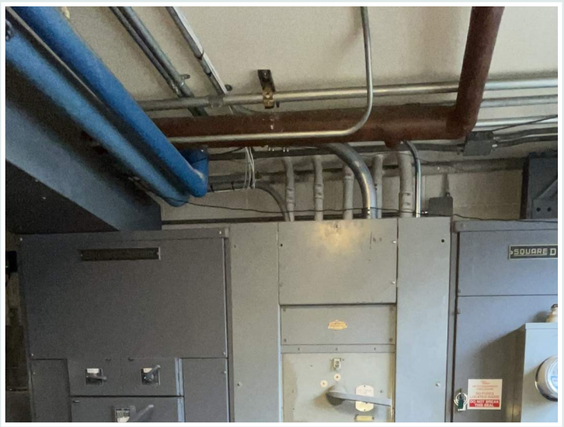
To accomplish this, the ground floor and first floor spaces on the north side must be on separate zones. New zones will be added by installing zone control valves in the spaces on both floors.

NEW THERMOSTATS

New thermostats should be Wi-Fi enabled and compatible with the other thermostats in the building. See Task 9—Controls. Thermostats in the northside of the first floor should be compatible with heat pumps, see Task 5. They should have a setting to activate auxiliary heating during very cold weather. The auxiliary heating signal will control the HHW zone valve.

RESOLVING CONFLICTS AT ELECTRICAL EQUIPMENT

Heating hot water supply and return pipes currently cross over the main electrical equipment in the boiler room. A leak in one of these pipes could cause serious damage to the electrical equipment or a fire. The pipes need to be rerouted to avoid crossing over the electrical panel. The blue pipes in the photo can be cut and rerouted within the boiler room. The brown pipe penetrates the ceiling above the panel and piping must also be rerouted on the first floor. If new piping will be added or rerouted for additional zones, that would be a good time to also resolve this conflict. Otherwise, it could be done during the boiler replacement.



Pipes cross over main electrical equipment in the boiler room.

1.6 – DHW RECIRCULATION

Getting hot water to the tap faster

TIMING
2024-2027

PROBABLE COST
$22,000

GOALS

- Reduce the wait time for domestic hot water at the tap
- Remove redundant equipment (dishwasher heater)
- Improve water pathogen control
- Prevent Scalding

DOMESTIC HOT WATER RECIRCULATION

In the existing system, when hot water is turned on at a lavatory or sink faucet all the water in the pipes between the tap and the water heater must pour out before the water heats up. This takes an excessively long time in the kitchen.

Adding a recirculation line to the end of the mains and a recirculation pump returns the water in the hot water mains back to the water heater and keeps the mains full of hot water. This reduces the wait time for hot water. Keeping the water flowing and hot also reduces the opportunities for pathogens such as Legionella to grow in the pipes.

There appears to be a capped DHW connection above ceiling over the kitchen sink where a recirculation line and balancing valve could be installed. The line would then route back to the water heater in the boiler room. An additional connection should be added to the main near the education wing restrooms. A circulation pump and mixing valve will be added at the water heater.

TIMER CONTROLS

Time clock controls should be added to the main DHW recirculation pump so that the pump only runs when the building is occupied. Since the kitchen is infrequently used, its recirculation branch or pump will activate when the lights in the kitchen are turned on or at the press of a button.

SCALD PREVENTING MIXING VALVES

Managing the temperature of a building's domestic hot water system balances controlling pathogen growth with scalding risk. Legionnaire's disease, a serious type of pneumonia, is caused when Legionella bacteria are aspirated or inhaled. The bacteria's growth range of 68°F to 122°F, means it grows in domestic hot water systems. To kill Legionella, domestic hot water should be stored at 140°F. Water cannot be delivered to most fixtures at this temperature due to scalding risk.

At 140°F, a person would receive first degree burns in 2 seconds. Young children and the elderly, with thinner skin and slower reflexes, face a higher scalding risk. For this reason, hot water is typically limited to 120°F or less at public fixtures with sometimes higher temperatures at commercial kitchen sinks and mop sinks. The Michigan Plumbing Code requires that water temperatures to accessible fixtures and lavatories be limited to 110°F.

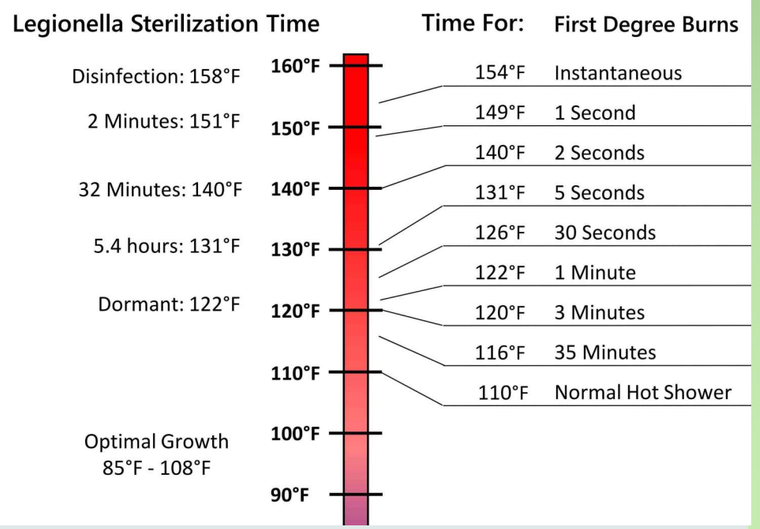
Domestic Hot water will be stored at 140°F. A mixing valve will combine this water with cold water to circulate the water at 120°F. Additional ASSE 1070 mixing valves at accessible lavatories would mix the water temperature to 110°F or lower. Alternatively, 140°F water could be circulated with individual mixing valves at each fixture.

DISHWASHER BOOSTER HEATER

An electric booster water heater in the air handling unit mechanical room heats water for the dishwasher. An hour prior to washing dishes, someone turns on the heater. The heater heats the water from 120°F to 180°F to sanitize the dishes in the dishwasher. We could not find a date on the booster heater, but it is at least 50 years old. When the existing dishwasher is replaced, a low-temperature model should be selected. Along with the proper washing agents, these models sanitize dishes at 140°F. This would remove the need for a booster heater.

A dedicated high temperature hot water line should by-pass the master mixing valve and supply 140°F water to the kitchen sinks and dishwasher.

Comparing Legionella Control and Scald Risk



3 — SANCTUARY ROOFTOP UNITS

Replacing equipment and improving cooling comfort

TIMING
2024-2026

PROBABLE COST
$50,000

EXISTING CONDITIONS

The Sanctuary is served by two, 8.5 ton rooftop units (HVAC-1 & 2) located on the courtyard roof of the kitchen. The units provide cooling and ventilation to the Sanctuary through high wall mounted grilles. The grille selection and location result in uneven cooling in the Sanctuary, with cold drafts on the pews near the windows and warm areas near the diffusers and in the balcony. The blue arrows and cloud represent this cold air in the figure at right.

Heating is provided by hot air from air handling unit 2 (AHU-2). The air enters from grilles under the windows and low on the opposite wall. There is some baseboard heating behind the choir loft.

REPLACEMENT CONSTRAINTS

HVAC-1 is 17 years old and is at the end of its expected useful life. HVAC-2 is 5 years old with another 10 years of useful expect life remaining. If air handling unit 2 (AHU-2) in the mechanical room was replaced with a new unit that included cooling, HVAC-1 could be demolished and not replaced. This would mean HVAC-2 would be demolished or made redundant with 10 good years unused.

The air distribution of AHU-2 is not ideal for cooling. Cold air drafts would be felt at both exterior aisles. AHU-2 can also not be simply abandoned because the rooftop units (HVAC-1 & 2) do not have sufficient heating capacity nor air distribution to heat all the areas of the sanctuary.

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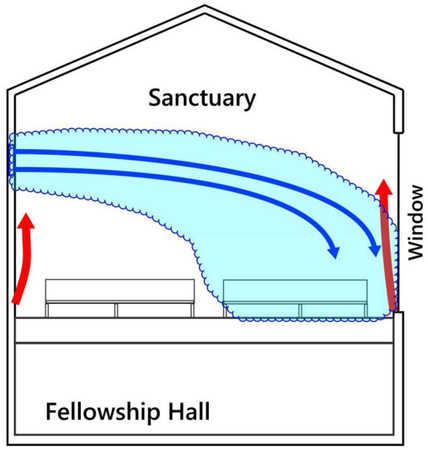
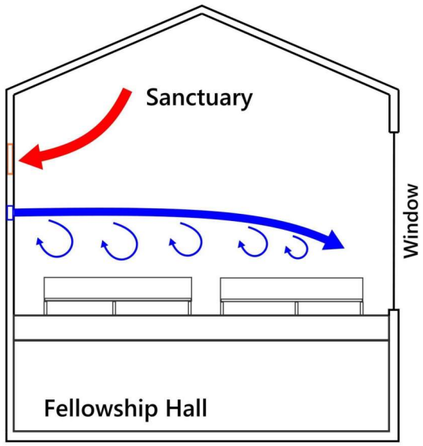


Existing section view facing balcony. Cooling from RTUs shown in blue. AHU-2 heat shown in red.



Future section view. Nozzle diffusers (below) project cold air across Sanctuary spreading cooling.

REPLACE ROOFTOP UNIT GRILLES

To improve the cold air distribution and comfort, the rooftop unit supply grilles will be replaced with high throw, nozzle diffusers. High speed jets will project cold air across the width of the sanctuary over the heads of the occupants. As the jets cross the sanctuary they will induce mixing vortices of room air that will cool the area below. The jets will be positioned to distribute air the length of the room. See image at left. Careful selection will be needed to find diffusers that have the needed throw (projection) and are quiet enough for the Sanctuary.

The new supply diffusers will be a different shape than the existing grilles and should be installed lower in the wall. The existing exterior ductwork will be modified to connect to the new diffuser locations. See the image at right.

RETURN AIR PATH

Currently, the return air passes through floor return mushrooms to the plenum of the Fellowship Hall Ceiling. Some air then returns to AHU -2 which is ducted into the plenum. The remaining air enters the kitchen ceiling plenum through holes opened in the block wall above the ceiling. The rooftop units' return ducts are open into the kitchen ceiling plenum.

Instead of sealing the opening from the existing supply grilles, they could be extended and made into return air grilles. The return air would then pass through exterior ductwork and enter horizontally to the units. The lower return air opening to the units could then be sealed. The new HVAC-1 would be ordered this way and we believe HVAC-2's return air connection could be field modified.

The holes in the kitchen ceiling plenum should be sealed to a fire rating as recommended by an architectural review.

NEW HVAC-1

The existing HVAC-1 will be replaced with a similar unit. HVAC-2 will remain.

SHORT-TERM VENTILATION

The occupancy used to calculate the ventilation is 220 people in the Sanctuary and 50 in the balcony. This would require a fresh air rate of 1670 CFM. An alternative ventilation calculation for short-term conditions is provided by the ventilation Code ASHRAE 62.1—2019 for large spaces with periods of high use followed by vacancy.

The short-term conditions ventilation calculation is summarized in the table below. Ventilation will start 1.5 hours before service and end 20 minutes after. The occupancy used to calculate the ventilation over this period is the averaged population. This requires a fresh air rate of 890 CMF. The existing rooftop units can handle this outdoor airflow rate.

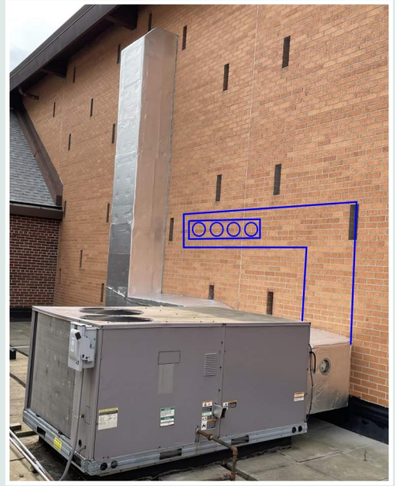
CONTROLS

A single new thermostat will be provided to replace the 4 existing thermostats. The new Wi-Fi thermostat will be compatible with the building wide requirements from Task 9—Controls.

The thermostat will control the rooftop units' fan and cooling. In occupied mode, the fan will run continuously. An auxiliary signal from the t-stat will signal occupancy to the economizer controller to open the outside air damper. In unoccupied mode the damper will close and the fan will only run as needed for cooling. An additional, field mounted, controller will control the heating to maintain a minimum supply air temperature of 65°F in ventilation mode.

The thermostat's heating output will send a signal to the sanctuary heating system described in Task—4.

	Period 1 Vacant		Period 2 Setup		Period 3 Service		Period 4 Exiting		Total Time	Average People
	Time (min)	People	Time (min)	People	Time (min)	People	Time (min)	People	(min)	
Sanct	60	0	30	20	60	220	20	30	170	**85**
Balc.	15	0	30	10	60	50	20	10	125	**28**



HVAC-1 existing supply will become return duct and new supply will connect to nozzle diffusers (blue).

Air transfer opening in block wall between Fellowship Hall and Kitchen plenums. Seal openings per an architect's direction.

GOALS

- Increase comfort during cooling
- Find replacement for aging HVAC-1
- Use remaining life of HVAC-2

TIMING

HVAC-1 is 17 years old and has an expected useful life of 15-20 years. Its replacement should be planned for within the next three years.

INITIATING STEPS

Contact Inclination Engineering for a quote to produce engineering design documents for the new unit installation.