ENVIRONMENTAL STEWARDSHIP ASSESSMENT

Winchester Unitarian Society

Winchester, Massachusetts

April 2021

This *Environmental Stewardship Assessment* is based upon information provided by the congregation, observations of the visible and apparent conditions of the property and the components evaluated on the date of assessment. Care has been taken in the performance of this assessment. This report is made only in the best exercise of our ability and judgment. However, Massachusetts Interfaith Power & Light (and or its representatives) makes no representations regarding latent or concealed defects that may exist, and no warranty or guarantee is expressed or implied. Conclusions in this report are based on systems attributes, estimates of the age and normal working life of various items of equipment and appliances. Predictions of life expectancy and the balance of useful life are necessarily based on industry and/or statistical comparisons and observed conditions. It is essential to understand that actual and future conditions can alter the useful life of any item. The previous use/misuse, irregularity of servicing, faulty manufacture, unfavorable conditions, acts of God and unforeseen circumstances make it impossible to state precisely when each item will require replacement and/or what the actual savings in use and cost will be. The Member herein should be aware that certain components with the above referenced property may function consistent with their purpose at the time of the assessment, but due to their nature are subject to deterioration without notice. Unless otherwise noted, all building components are assumed to have met the building code requirements in force at the time of construction. Conclusions reached in this report assume responsible ownership and competent management of the property. Information provided to us by others is believed to be reliable. However we assume no responsibility for the accuracy of such information.

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Table of Contents

This *Environmental Stewardship Assessment* is based on a site visit to Winchester Unitarian Sociecty *House Of Worship* (HOW) on February 21, 2021, by Jim Nail and Bill Schroeder for Massachusetts Interfaith Power & Light (MassIPL), and a follow-up visit by Jim Nail on April 10, 2021. The report provides a summary of conditions and "To Do" list, followed by findings that will help guide you as you make the recommended improvements, it can easily be shared with other members of your congregation, in print or electronic format.

Also review the ***Everyday Environmental Stewardship Briefs*** and ***Case Studies*** which are sent separately.

These provide detailed guidance on the actions possible at your HOW, and at all the places we occupy as we live, work, study, and play. ***Case studies*** of interest are also presented. It helps to know what others with similar circumstances have done.

Remember also that the observations for this House Of Worship apply as well
to the houses in which we live, work, learn and play.
Be active in caring for them all.

If We Don't, Who Will?

SUMMARY

This summarizes the energy use, environmental and financial impact, and the rating of Winchester Unitarian Society for its environmental stewardship. Due to the impact of the pandemic reducing building use (and thus energy use) in 2020 this report will use 2019 as a more representative year.

Energy Use Intensity: Slightly Above Average

Energy use intensity (EUI) measures the amount of energy used annually per square foot of building space. It is a standard measure used in the energy efficiency field. The Energy Information Administration reports that the average House Of Worship (HOW) has an EUI of 50. It also reports that HOWs are the **worst** building types for energy use. Thus just being "average" as a HOW is not a good rating for environmental stewardship. Your HOW is 52.9 and our evaluation finds a number of ways to reduce this further.

Carbon Emissions: Below Average

Different types of energy emit different amounts of carbon, with heating oil emitting the most. Gas and the fuels used to generate electricity also emit carbon so reducing all energy use is important. The recently-enacted Next Generation Roadmap for MA Climate Policy Bill calls for Massachusetts to reduce carbon dioxide emissions by 50% by 2030 (vs 1990 baseline) and be net zero by 2050, in line with scientists' recommendations to avoid the worst effects of climate change. WUS has done an excellent job reducing your carbon footprint since 2004, beating the goal of the 2008 Global Warming Solutions Act of a 25% reduction by 2020. But there is still significant potential to decrease your carbon footprint in each of the four areas this report examines: Behavior, Electricity, Building Envelope, and Heating/Cooling/Hot Water.

Financial impact: Below Average

Winchester Unitarian Society spent $24,929 in 2019 for all its energy use, approximately 3.6% of its overall budget. MassIPL sees a range of 2% - 20% -- so WUS is at the low end of the range. Congratulations! Green grows two ways – one of which you take to the bank! By implementing the recommendations in this report you can reduce this cost and reinvest the savings in additional energy efficiency measures caring for creation, which is a key element of your mission. MassIPL sees savings in a range of 10% for the "low-hanging fruit" to over 50% for the major work. All actions have continuing benefits, for decades or more.

Your 24 Questions Score 8 YES; 10 NO; 6 YES & NO

The following page presents the answers to the 24 Questions on environmental stewardship at your HOW. A perfect score would be answering all 24 questions YES. Currently Winchester Unitarian Society can only answer 9 questions. However these NO answers and YES & NO answers reveal the most important opportunities to decrease energy use, save money and improve your environmental stewardship.

Winchester Unitarian Society

Question	*Answer*	*Comments*
BEHAVIOR		
Do you track your Utility Use and Cost (UU&C) monthly?	YES	Now that you have started, keep it up on a monthly basis!
Have you created energy awareness among staff and members?	YES & NO	Signs in a number of areas remind people to turn off lights. Space heaters in various rooms indicate more awareness needs to be created.
Do you have a designated "energy manager"?	NO	Chuck is doing much of the work on the energy manager. Document his knowledge and recruit an "assistant" so more than one person knows about your complex heating system.
Do you have an environmental stewardship team?	YES	The team has done some educationnal events in the past. Now develop a charter for the team to share the success to date at WUS and inspire them to follow this example at home!
Do you know and minimize your Carbon Footprint (CF)?	YES	You now know your carbon footprint. Buying 100% green electricity shows your commitment.
Have you created a budget line for Energy Efficiency investments?	NO	This will be an important action to prepare for the major projects MassIPL is recommending.
ELECTRICITY		
Do you make best use of natural and artificial light?	YES	The architecture requires artificial light in most areas most of the time.
Do all your fixtures have LED bulbs?	YES	WUS engaged MassSave for an extensive lighting retrofit in 2019.
Is your lighting dimmable?	NO	The old dimmers for the Sanctuary lighting are likely incompatible with the new LED lighting. Dimmers were not seen in other areas.
Do you have sensing switches in appropriate spaces?	NO	Bathrooms especially would benefit from installing sensor switches
Are all your appliances and equipment *Energy Star* "top" rated?	YES & NO	Make it a habit -- and maybe a policy -- that when refrigerators, office equipment, etc. are replaced that the selection emphasizes high ranking on the Energy Star list.
Have you evaluated your HOW for solar panels?	YES	WUS has a 18.72 kw solar array that went into operation in March 2012. Recent performance indicates it may need maintenance.

Question	*Answer*	*Comments*
BUILDING ENVELOPE		
Have you created heating/cooling zones that match use patterns?	YES & NO	This is a work-in-progress. The heating system is complex and changes over the years have created uncontrolled areas. Chuck Khuen is developing a plan to remedy this.
Do thermostats control temperature compatible with use and time?	YES	One thermostat was found to be set to the incorrect time but otherwise good attention is being paid to them.
Do you keep doors closed between heating and cooling zones?	YES & NO	On the MassIPL site visit, doors between zone seemed to be closed. Ensure consistency in this action, especially by make staff aware of its importance.
Have you sealed areas of air infiltration?	NO	The "snowblower room" needs a door sweep, weatherstripping around the exterior door, and possibly insulation adhered to the doors. All doors need to have the weatherstripping inspected and
Are your walls, ceilings, floors insulated?	NO	Ice dams indicate roofs are not insulated. In the RE Wing, the roof has minimal insulation with an opportunity to install much more.
Do you have high efficiency windows? Interior storms? Sun screens?	NO	Significant opportunity to reduce air infiltration through and around old leaded glass casement windows with interior storm windows where they are not currently in place.
HEATING COOLING WATER		
Is your boiler or furnace 95%+ efficient?	NO	Steam systems are inherently inefficient. The system has about 10 years of expected life, so beginning planning now for a fossil-fuel-free replacement.
Is your domestic hot water heater 95%+ efficient?	NO	The Ruud tank water heater is likely no more than 65% efficient.
Is your air conditioning SEER 14+?	NO	Office air conditioner appears to be past its useful life. Replace and upgrade with a heat pump.
Do you have controls that optimize energy efficiency?	YES & NO	Timer controls on boiler and individual radiator controls
Are heat/AC means of delivery efficient?	YES	The pipes of the heating system appear to be well insulated. The A/C in the office has short runs with flex duct so likely little air leakage.
Do you have water-efficient faucets and toilets?	YES & NO	Toilets all appear to be 1.8 gallon per flush, so relatively good. Consider installing dual flush mechanisms.

To Do Summary

Short Term

There are a number of small to modest-size actions that WUS can take this year and within the next couple of year that will continue the work you have done to reduce energy use, cost, and carbon footprint:

1. Schedule a MassSave Assessment and discuss the following with the assessor:
    a. Rebates and incentives available for upgrading to smart, wi-fi enabled thermostats
    b. Replacing the office A/C with a heat pump. Ask about your eligibility for a 0% interest loan.
    c. Weatherstripping all doors. Possibly replace the Music Director Office and the "snowblower room" exterior doors.
    d. The feasibility of adding insulation above the ceiling in the Parlor, Michelsen, RE Director's office, Music Director's office.
    e. The feasibility of adding insulation above the ceiling in the top floor of the RE Wing.
    f. Incentives available for replacement of the gas stove in Metcalf Kitchen.
    g. Incentives available for replacing the hot water tank with an on-demand system.
    h. Eligibility for the major renovation program, should you decide to pursue the items in the Net Zero Agenda below. https://www.masssave.com/en/saving/business-rebates/new-buildings-and-major-renovations
2. While you should ask the MassSave assessor about the following projects, they may not be covered by MassSave. They are relatively easy and modest cost so should be budgeted and completed over the next couple of years:
    a. Inventory windows without inserts/interior storms and plan to either make or buy them.
    b. Add an exterior storm to the one Winsor window without it
    c. Attach rigid foam insulation on the closed-off door in the "snowblower room"; if the door to the exterior is not replaced, add insulation to this one also
    d. Make or buy summer window inserts for the offices, with either sun screens or reflective film to reduce solar gain and thus use of air conditioning.
    e. Insulate pipes from the hot water heater in the boiler room wherever they are accessible.
3. Call Pegasus Energy and ask them to check that all solar panels and microinverters are functioning correctly. They likely can do this via the online interface. If not, they should make a site visit to test these components.

To Do Summary (continued)

Longer Term: Net Zero Plan

In enacting the Next Generation Roadmap for Massachusetts Climate Policy, the state set the goal to achieve net zero carbon emissions by 2050. The overall strategy is to reduce carbon emissions as much as possible, then offset what can't be eliminated. WUS is well on its way but two major projects should be considered to align with this goal:

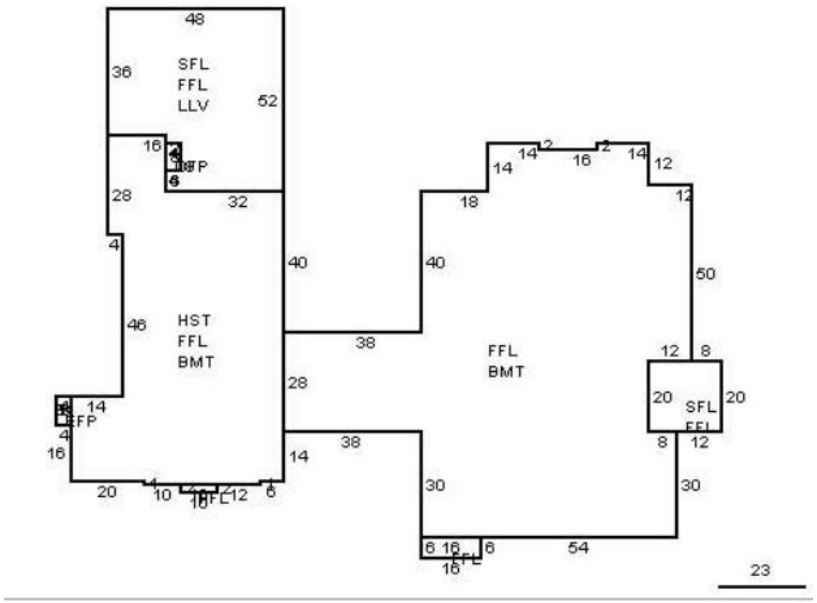
1. Replace the gas-fired steam heating system with heat pumps. The boiler is about 2/3 through its useful life, so will likely need replacing in the early 2030's. The state has explicitly stated the need to eliminate fossil-fuel-fired heating systems and convert to heat pumps. Begin evaluation and planning within the next couple of years as new programs and incentive will likely become available.
2. Retrofit the RE Wing. In addition to ceiling insulation described above, the building could be made substantially more energy efficient by applying exterior insulation and replacing the window assemblies. With this improved insulation and air sealing, remove the RE Wing from the steam boiler and install heat pumps. MassSave's major renovations incentives should apply to this project and would pay part of the consulting and design fees as well as incentive payments based on the projected amount of energy saved. In addition, MassIPL expects the state to create new incentive programs in the coming years as it works to implement the legislations.

Winchester Unitarian Society Photos--

The Building and surrounding area.

Aerial view of Winchester Unitarian Society, showing the Sanctuary in the middle, and the RE Wing with solar panels to the lower right

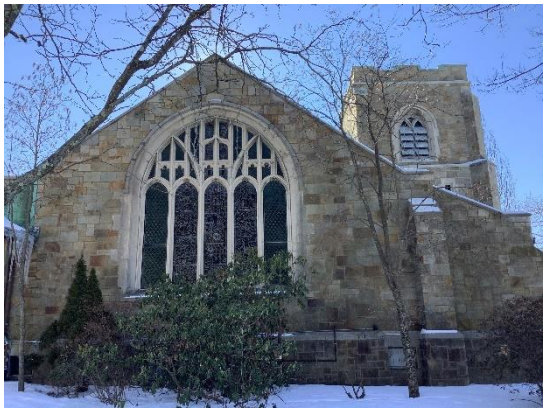
The 1898 cornerstone. Houses of worship should think in the long term about investments in their energy-using equipment.



Footprint of Winchester Unitarian Society. Here, the Sanctuary is to the upper right with the RE Wing to the left.
Source: Patriot Properties, Winchester Assessor's Database

Winchester Unitarian Society's commitment to being responsible environmental stewards is affirmed by this 2010 Energy Star designation.

View from across Main Street to the entrance to the office area, with Michelsen to the left.



Large stained glass windows in the Sanctuary and Symmes give the building a striking appearance.

The rear of the office area, with the Sanctuary on the left, RE Wing on the right.

Unfortunately, as the blue areas in this infrared photo show, these windows are inefficient, and they are challenging to improve.

View of the RE Wing, with the entrance used by the preschool.

The rear of the RE Wing with the playground used by the nursery school.

FINDINGS

Winchester Unitarian Society has made significant strides in lowering its carbon footprint since 2004 based on UU&C data MassIPL collected in 2005 and copy of the full report accompanies this one. In total, WUS's carbon footprint in 2019 is 60% lower than it was in 2004, exceeding the Commonwealth's goal in the 2008 Global Warming Solutions Act to reduce carbon emissions 25% by 2020. Congratulations! Switching from oil to gas cut almost 140,000 pounds of carbon. (Note that this calculates only emissions from gas burned on site and does not include the global warming impact from gas that leaks from pipelines which will reduce this savings though it is hard to calculate.) Other heating system actions including blocking old outside air intakes, installing a timer on the boiler, maintenance of steam traps and other actions have reduced heat use by 61% in BTUs (British Thermal Units).

BEHAVIOR

We generally take energy for granted. If we do think about energy, it is usually when we get a big bill! But cost is the result of how we use energy, and **use** reflects our behavior. Behavior is volitional. We can change it and thus lower the cost (in $s and environmental impact) of our energy use. Follow the low cost/no cost ways to reduce energy use in this section and you may save up to 15%.

Do you track your utility use and cost monthly? Yes

You have begun, now be sure to update the UU&C spreadsheet monthly and review it regularly to identify unusual patterns that can indicate attention is needed. Using the MassIPL *Utility Use & Cost* spreadsheet for all utilities is an effective way to know the impacts and cost (in $s and pollution) of one's behavior, as a congregation or an individual.

Though we usually just focus on the financial cost for utilities, it is imperative that we are also aware of the environmental and health impacts. The spreadsheet calculates the carbon footprint of your HOW as a first step in your environmental stewardship journey.

The summary of Utility Use and Cost information for Winchester Unitarian Society is below. Cost for utility use is financial, but also and importantly environmental, including in particular health impacts. The volume and cost of utility use is fertile grounds for improved environmental stewardship. For more information, see MassIPL's *EES Brief* on *UU&C.* There are savings to be achieved (in the 10% range) simply by using *PowerOptions* to "bulk-buy" gas. See information included as an attachment.

Utility Use Summary from 2005 Building Condition Summary Report Prepared by MassIPL (then known as MIP&L)

SUMMARY OF UTILITY USE
Winchster Unitarian

	ELECTRICITY		GAS		OIL		WATER & SEWER	
YEAR	$s	KWH	$s	THERMS	$s	GALLONS	$s	VOLUME
2 Years Ago								
2003	$3,136.73	25,742	$1,319.61	582	$17,188.38	16,369.9	$598.66	74
1 Year Ago								
2004	$6,734.18	53,886	$2,686.99	684	$23,343.75	18,710.5	$1,480.47	183
% prior year	215%	209%	204%	118%	136%	114%	247%	247%
Current Year								
2005	$5,818.89	40,282	$1,984.32	331	$29,795.46	16,398.3	$242.70	30
% prior year	86%	75%	74%	48%	128%	88%	16%	16%
% 2 years ago	186%	156%	150%	57%	173%	100%	41%	41%

NOTE: Oil data estimated. See utility for specifics. Other data insufficient for estimates.

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In 2004, WUS had a carbon footprint of 213 tons due to oil, 4 tons due to gas, and 23.5 tons due to electricity for a total of 240.5 tons.

Summary Page of UU&C Prepared for this report

SUMMARY OF UTILITY USE & COST													
Winchester Unitarian Society													
				insert Sq Ft here	31,000	*square feet*							
		ELECTRICITY		Cooling	GAS		Heating	OIL		PROPANE		WATER & SEWER	
YEAR	TOTAL	$s	KWH	Degree Days	$s	THERMS	Degree Days	$s	GALLONS	$s	GALLONS	$s	VOLUME
2018	**$32,659**	$8,131	51,562	1,785	$18,321	14,540	4,218	$0	0.0	$0	0.0	$6,207	431
CO2 lbs	*190,816*		*20,698*			*170,118*			*0*		*0*		
% of prior year	*749%*		*81%*			*#DIV/0!*			*#DIV/0!*		*#DIV/0!*		
kBTU per SF	**52.6**												
% prior year	**356.9%**	108.5%	92.2%	116.5%	#DIV/0!	#DIV/0!	102.0%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	375.3%	188.2%
2019	**$24,929**	$4,779	31,356	1,487	$18,458	15,328	4,100	$0	0.0	$0	0.0	$1,692	112
CO2 lbs	*192,932*		*13,594*			*179,338*			*0*		*0*		
% of prior year	*101%*		*66%*			*105%*			*#DIV/0!*		*#DIV/0!*		
kBTU per SF	**52.9**												
% prior year	**76.3%**	58.8%	60.8%	83.3%	100.7%	105.4%	97.2%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	27.3%	26.0%
2020	**$17,109**	$2,778	24,416	1,571	$13,318	10,715	3,813	$0	0.0	$0	0.0	$1,013	57
CO2 lbs	*138,246*		*12,880*			*125,366*			*0*		*0*		
% of prior year	*72%*		*95%*			*70%*			*#DIV/0!*		*#DIV/0!*		
kBTU per SF	**37.3**	$0.09	1		$0.43	0		$0.00	0	$0.00	0	$0.03	0.001838709677
% prior year	**68.6%**	58.1%	77.9%	105.6%	72.2%	69.9%	93.0%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	59.9%	50.9%

In 2019, WUS's overall carbon footprint was 95. tons, down over 60% from 2004. Congratulations! The vast majority of this still comes from gas for heating the building: 90 tons. Note that although the bulk of your electricity comes from your solar panels, since Pegasus owns and sells the SRECs, you cannot claim it as carbon-free electricity yet. In any case, you have added carbon-free electricity to the grid and that is a good thing!

Use Patterns

Use for heating should vary in direct relation to heating *Degree Days*. The % change by the congregation at the end of the year should be about the same as *Degree Days*. If the use % is higher, it indicates increasing inefficiency by the congregation. Monthly tracking and comparison with the same month in prior years (adjusting for Degree Days) is also an important indicator in understanding your HOW use patterns.

To learn more about how to use the Utility Cost & Use spreadsheet to lower your energy costs, read the MassIPL's *Everyday Environmental Stewardship Brief* on *UU&C*.

Evaluation

Electricity use declined 40% from 2018 to 2019 apparently due to upgrading to LED lights, limiting use of roof heating cables to only when conditions warrant (vs having them on throughout the winter) as well as similar limiting the use of a space heater in the "snowblower" storage room.

Gas use in 2020 was down 30% vs 2019 while the 2020 Degree Days were down 7% compared to 2019. This shows good management of the heating system in response to the lower building usage during the pandemic.

Have you created energy awareness among staff and members? Yes and No

Nothing can change if nobody is paying attention. A life of faithful behavior needs help, which of course is one of the reasons we gather as religious communities, to talk, share and worship. Energy awareness prompts faithful behavior. Start with the HOW by including carbon footprint and energy use reports at meetings of the governing body as well as the annual report to the congregation. Then educate the staff and congregation that the actions discussed in this report can also be done at home, business and school, all the places we go in our lives.

Include discussion of energy at least twice a year in staff meetings: in the spring at the switch from the heating season to the spring/summer cooling season and in the fall at the beginning of the heating season. Remind staff to be aware of closing doors between zones, how to adjust thermostats temporarily when necessary without affecting the programmed times, and encourage them to report cases where rooms seem warmer than necessary.

Evaluation

This answer indicates some work has been done but there is more to do. There are signs reminding people to turn off lights in several areas (eg, the accessible bathroom and the door to Metcalf Kitchen, see Photos B-1 and B-2). In addition, the presence of space heaters in the

offices, Michelsen (see photo B-3) indicate discomfort that should be addressed through improvements other than inefficient heaters. Review staff schedule and schedule of outside groups using the space to be sure the thermostat programming is kept in synch with building usage.

Do you have a designated "energy manager"? Yes and No

Awareness moves to action when responsibility is clear. Just as a HOW has a lead person for *worship*, so also does it make sense to have a lead *energy manager*. Simply put, their role is to monitor energy use and find ways to reduce it. The energy manager for your HOW should do several things: update the Utility Use & Cost sheet every month, look for unusual spikes in energy use and, if found, investigate the cause; share findings with committees including the environmental stewardship/green team, finance, property, and the lay leadership; update the Space Use sheet twice a year (October and March) and use the information to update programmable thermostat settings. Finally, the energy manager should ensure that energy-using equipment (especially boilers, furnaces, and air conditioners) receive regular routine maintenance to operate as efficiently as possible. The energy manager could be any member of the congregation with an interest in saving energy. Now that you have started the UU&C spreadsheet, it only takes a few minutes each month to update it.

Evaluation

Given the size of the building, the complexity of the heating systems, and the proven savings by being mindful of energy use by systems like the roof cables, this is an important position for someone to take on. If no one keeps an eye on these systems on a regular basis, it will be easy for energy consumption to return to previous higher levels. Chuck Khuen has been fulfilling this role 'unofficially', but the role should be more formal. The systems should be documented in writing (this report is a good start) and the person who becomes energy manager now should ensure that there is at least one other person knowledgeable about the systems and processes. When the current energy manager "retires" from the position, he/she must ensure that the new person is fully educated on the tasks required.

Do you have an environmental stewardship team? Yes

The energy manager's responsibilities are sensibly aided by HOW members (here labeled *Environmental Stewardship Team*) organized to provide technical, practical and instructional help. Some of the recommendations in this report will require planning and management that is best done by a group of people who share this concern, can support each other and can convey the stewardship actions to the congregation and beyond.

Evaluation

On the site visit, we were delighted to see three members of WUS's environmental stewardship team. This is a great start. In addition, there is an informational poster in Symmes about the Green Sanctuary program, WUS' participation in the WinPower 100% clean electricity program, encouragement of members to join the program, and a November 2019 program on the book Drawdown (see Photo B-4). All these are excellent examples of the types of programs the Environmental Stewardship team can run. A next project this group could take on is to educate the congregation about your progress to date and educate them on how to achieve similar carbon footprint reductions in their homes. The church example should inspire members by showing them what is possible with careful thought, attention, and action. This will be a very

timely project as the Commonwealth embraces the goals in the new Next Generation Roadmap for MA Climate Policy Bill. Achieving these goals will require every individual, business, and organization to follow WUS' example.

Do you know and minimize your carbon footprint? Yes

The Utility Use & Cost spreadsheet calculates your carbon footprint – that is, the amount of carbon your HOW is responsible for adding to the atmosphere. In addition to reducing the energy you use, you can reduce your carbon footprint by buying carbon offsets or committing to 100% Green Electricity, this and all years. Although Green Electricity and carbon offsets add money to your energy budget it will be less than the amount you save through other actions recommended in this report and so is an affordable way to further lower your environmental impact.

Evaluation

WUS carbon footprint in 2019 was 90 tons, down from 240 tons in 2004. Note that although most of your electricity comes from the solar panels on the RE Wing roof, you cannot claim it to be zero carbon electricity. Under the terms of your contract with Pegasus, they own the Solar Renewable Energy Credits (SRECs) which are the embodiment of the low carbon characteristic of solar power. Pegasus in turn sells them, likely to Eversource, and the utility uses them as part of their compliance with the Massachusetts Renewable Portfolio Standard that requires them to have 15% renewable energy. SRECS are only issued for the first 10 years of operation, then "regular" RECS are issued; check with Pegasus if they will sell those or whether you own them. Also, should you buy the panels, if you do not sell the RECs, you will be able to claim this as carbon-free electricity.

WUS has already committed to 100% green electricity through the Winchester Community Aggregation program, WINPower, so that the electricity not produced by your solar panels is carbon free (see Photo B-5).

Have you created a budget line for energy efficiency investments? No

In considering costs (especially for capital actions), recognize that "return" on such investments for the community-of-faith is measured by the standards of the kingdom of God, not the kingdom of Wall Street. The decisions being made speak to the care we are called to give to the earth, as stewards of God's creation. The age of the building—dating to 1898 with the "youngest" work over 30 years old—conveys the appropriate time horizon.

An *energy efficiency budget* starts with current $s, BUT it also adds a line, *energy efficiency*. The projected savings from line items (electricity, gas, oil, propane, water/sewer) as a result of energy efficiency actions are shown in this line, with $s invested in energy efficiency actions. For example, if programmable thermostats are installed replacing manual thermostats with a savings estimate of 10%, and last year's gas bill was $10,000, then the next budget would show $9,000 for gas and $1,000 for energy efficiency. The $1,000 can then be used in the coming year for other actions, such as the HOW's share of LED bulbs after the electric company rebates. If no actions are taken in the year, the funds are set aside in a *Energy Efficiency Reserve Account* for use in future years. This is illustrated in the sample Efficiency Budget at

Appendix C, the % of the Efficiency line increases over 4 years from 14% to 41%. The $s are a huge help in paying for moderate-cost items (such as recommended interior storm windows) and also preparing for major work, such as a major heating system replacement.

An immediate step to start saving is to enroll in a program for **bulk purchase** of gas and electricity and use the savings to fund the energy efficiency budget. One such bulk buying program available to Winchester Unitarian Society (and other non-profits) is *PowerOptions*. Go to www.PowerOptions.org.

Another way to fund the energy efficiency budget is to adopt your own internal fee on carbon. A fee like this is meant to internalize the cost that carbon pollution and the effects of climate change inflict on others and society at large. Many corporations use this approach, putting a price on carbon ranging from $15 to $50 per ton. One approach would be to follow Canada's example: they started at $10 per ton of carbon in 2018, increasing by $10 per ton until the price reaches $50 per ton in 2022. Use the funds raised by this mechanism to implement the recommendations in this ESA and establish a reserve fund to save for large projects in the future.

Evaluation

Had WUS not taken the energy savings actions it has since 2004, its 2019 energy costs would have been nearly $60,000 or $36,000 higher than 2019 costs. Had WUS put this savings into an Energy Efficiency Reserve, you'd have a sizable amount to tackle the recommended energy conservation measures in this report!

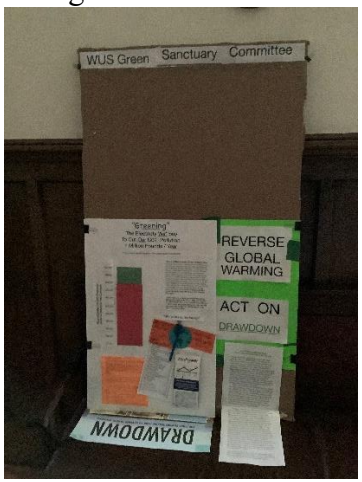
Begin by thinking about what future energy costs are likely to be if you do nothing; you can expect your energy costs to increase at least at the rate of inflation. For convenience, let's use a 3% annual inflation rate. Thus, the $24,959 spent in 2019 would have been expected to be $25,708 in 2020 absent the pandemic, $26,479 in 2021, etc. Budget for this inflation-adjusted amount and when you reduce energy costs, put the savings into your Energy Efficiency Reserve.

The bulk-buying option is a quick way to begin to fund additional efficiency actions – 10% savings on your gas bill would provide $1800 annually to your Energy Efficiency Reserve! If you sign up for the bulk purchase option for your gas, use the savings in 2021 to begin to fund the energy efficiency budget, and possibly implement some modest actions. Track 2022 energy costs and use the difference between the inflation-adjusted expected and actual costs to contribute further to the budget line.

Create this budget line in 2022 and fund it with expected savings from the 2021 actions. Should you buy the panels, direct the dollars that paid the PPA to the energy efficiency budget line.

BEHAVIOR Photos

B1 — This sign in the accessible bathroom reminds people to turn off lights.



B4 — This poster in Symmes educates the congregation about a number of Green events and actions by the church.

B2— This sign on the door near Metcalf Kitchen reminds people to turn off the lights when they leave.

B5 – Displaying this sign sets and example for the congregation and community about buying green electricity to accelerate our progress toward renewable energy.

B3 — The presence of space, heaters like this one in Michelsen, indicates areas of discomfort that should be investigated and corrected.

ELECTRICITY

Electricity is costly, and is a significant cause of environmental pollution. Lighting, office and kitchen equipment, and air conditioning (if used) are key uses of electricity where upgrades in equipment and use practices typically are possible.

The amperage of electricity service at Winchester Unitarian Society is not known and you should ask your electrician the next time he or she is working in the building. The electrical panel is extensive; the meter for the solar panels is at the left in the phot provided (See photo E-1.) The building has grounded wiring, with no knob-and-tube (ungrounded) wiring.

Do you make the best use of natural and artificial light? Yes

Lighting is likely to be one of the largest users of electricity in your HOW. Depending on the orientation of the building to the sun and the location of rooms, daylight may be sufficient. When there is sufficient daylight, avoid turning on lights. When lights are used, the level should be appropriate for the activity. For example, offices, classrooms, and music rooms need sufficient light so people can read without straining their eyes. Areas such as hallways or entries need lower levels of light but are often overlit. If an area seems too bright, try removing a bulb or two from a fixture or switch bulbs to a lower wattage. You can often reduce electricity use 20% or more in these areas by this simple, no-cost action.

Evaluation

While our visits were on Saturdays when there was no activity in the building, the amount of lighting in rooms and hallways seemed appropriate. Because of the age and construction of the building the interior is relatively dark, so natural light alone is likely insufficient. One opportunity may be in the offices: their south-facing orientation means they get good sunlight and on many days this may be sufficient. However, the tendency is to walk into a room and flick on the lights without thinking about it. Ask staff to try working without lights on sunny days and use desk lamps if additional light is needed. But, of course, their health, comfort, and effectiveness in their jobs is most important so if they feel that this is not sufficient, then they should turn the lights on. The important thing is to make it a conscious choice based on need, not an unconscious reflex!

Do all your fixtures have energy efficient bulbs? Yes

The benefits of efficient lighting are well known. Updating lights is easy and have an immediate impact on your electricity use. LED bulbs are superior to both incandescent and fluorescent lighting in both lower electricity use (50>85%) and longer life (10>50,000± hours). The longer life also means the time and cost to change bulbs is significantly reduced, an important consideration in hard-to-access locations, such as sanctuaries and other big/high rooms. Utilities offer a substantial rebate (70%±) for converting to LEDs as part of an audit, essentially making price a non-issue given the significant operating cost reduction. At the big home centers, there is a “silent rebate” in which the MassSave program pays the retailer part of the wholesale cost and the retailer passes that cost on to the consumer through lower prices. Most LED bulbs are in the $1 - $3 range at these stores.

Evaluation
Winchester Unitarian Society has taken advantage of the MassSave program and upgraded almost all of its lighting to LED in 2018, with a number of different lighting fixture types evident (see Photos E 2- E-5). There are many different styles available and there may be a more appropriate style (e.g., for fixtures like the sconce in Photo E-2); check the selection at the large home centers or go online to sites such as www.1000bulbs.com. Some exit signs appear to have LED replacements in the (see Photo E-6) but the exit signs in Metcalf hall may still have incandescent lighting (we did not open them during the site visit); online sources will likely have LED retrofits. Exit signs are on 24x7x365 so their electricity usage adds up While we found a handful of incandescent bulbs in other locations on our site visit, they are in little used spaces and don't contribute significantly to electricity use. However, they should be replaced and LED bulbs of all types are widely available.

Is your lighting dimmable? No

The amount of lighting needed varies by time of day, exterior conditions (bright sun>dark clouds), and the amount of natural lighting possible. Thus the ability to dim has the benefit of not only matching lighting amount (therefore cost) to these variables, but also to the nature of activity in the lighted space. For example, processing in to a worship service is typically brightly lit, while the time of prayer is appropriately with low levels of lighting. Note that LEDs require compatible dimmers which should be installed when the lights are switched. An important benefit of LED dimming is that electricity use is reduced proportionally.

Evaluation
When the Sanctuary lights were upgraded to LEDs, the lighting controls were not upgraded. As a result, the dimming capability likely is not compatible with LEDs. They are located outside the boiler room and so not convenient to use in any case, and the array of dials is confusing and intimidating (see photo E-7). There aren't dimmer switches in other rooms. A modest savings of electricity can be achieved with dimmers so if any electrical work is done around the building, consider installing dimmers.

Do you have sensing switches in appropriate spaces? No

Some spaces are well served by having ***occupancy/vacancy*** sensing switches for lighting control. Restrooms are the prime candidates, with storage rooms another strong possibility. These spaces have multiple users, with highly variable use patterns. Having a motion sensor switch (typically at the entry) that is also calibrated to typical use time means the use pattern (aka *behavior*) is monitored by technical equipment that ensures efficient on/off of electricity for lighting.

Evaluation
On the site visit, we saw no motion sensing switches. Begin by installing them in the bathrooms and meeting rooms that outside groups use, especially if you have had experience in the past where they have forgotten to turn off lights when they left.

Are all your appliances and equipment Energy Star "top" rated? Yes & No

Equipment using electricity is found in offices, kitchens, music rooms and other locations. Computers, printers, copiers, space heaters, refrigerators, dishwashers, humidifiers and dehumidifiers are the most typical sort of such equipment. Refrigerators and freezers typically consume the most electricity of any of these appliances so be sure to replace models older than 20 years and pick the most energy efficient model available. The ***Energy Star*** program is well known and an excellent guide to finding the most energy efficient equipment to replace older products. But don't just buy any Energy Star product – look for ***Energy Star*** Top Rated. Use the ***Energy Star*** web site to get the best! This ensures both lower electricity use, but likely also longer life for the equipment. Go to

http://www.energystar.gov/certified-products/certified products?c=products.pr_find_es_products

The governing body should adopt a resolution that all new equipment purchased in categories that the Energy Star Program covers should be top-rated, and then apply this policy in all new purchases.

Evaluation

There are three refrigerating appliances:

- Boiler room – A Frigidaire 17 cubic foot standing freezer manufactured in 2015 (see Photos E-8 and E-9). It carries an Energy Star label and is rated to consume 431 kwh per year. This is good efficiency and has many years of useful life. However, there was relatively little in it, so perhaps it could be turned off, with the food moved to the freezer section of the Metcalf Pantry refrigerator.
- Metcalf Pantry -- This is a Frigidaire 21 cubic foot top freezer model manufactured in 2009 (see Photos E-10). This is a reasonably efficient model and the EPA Flip Your Fridge Calculator estimates it uses about 651 kwh per year while a new similar model uses about 450 kwh, saving about $50 per year and roughly 200 kwh. There is no immediate need to replace this appliance.
- Symmes Room Kitchenette -- this is a small Haier beverage fridge. No label with a model number was visible but it appears to be fairly new thus is likely relatively energy efficient; appliances this size are rated to consumer only about 200 – 300 kwh per year. However, it was empty and the temperature turned down to the point that there was extensive ice forming on the coils inside (see Photo E-11). Consider turning it off completely until in-person worship and use of the building returns to normal.

In addition, there are two dishwashers. First, a large commercial model in the Metcalf Kitchen of unknown age and efficiency (see Photos E-12 and E-14). Second, there is an under-counter commercial model in the Symmes kitchenette (see Photos E-13 and E-15); it is also of unknown age and efficiency. Neither is listed on the Energy Star web site. Both should be evaluated by the MassSave auditor for incentives that may be available for replacements.

In the office, there was no large copier, just several small desk printers which are not a cause for concern, especially if there are turned off when staff leaves for the night.

In addition to these appliances, there is a gas range and pizza oven which we will include in this section. The gas range uses a pilot light instead of electronic ignition; so small amounts of gas are burned 24x7 and it adds up over the year (see Photo E-16 and E-17). A new range would use electronic ignition, or you may want to eliminate gas entirely and upgrade to electric induction cooking. MassSave has good incentives for upgrading commercial kitchen appliances like these.

Have you evaluated your HOW for solar panels? **Yes**

Winchester Unitarian Society was an early adopter of solar panels, installing an 18.72 kw array consisting of 78 Mage 240 watt panels with Enphase microinverters (see Photo E-18) that became operational in March 2012 through Pegasus Renewable Energy. The system is located on the flat roofs of the RE Wing and office area and the disconnect switch is locate on the south exterior where Metcalf Hall meets the Office section of the building (see Photo E-19). The system produces about 20,000 kwh of electricity in a typical year, or about 67% of your typical annual electric usage.

Evaluation

The contract with Pegasus is a power purchase agreement, under which Pegasus owns the system and the Solar Renewable Energy Credits and sells the electricity to WUS at a 70% discount from "what the Landlord/Purchaser would have otherwise paid for the power at that time." While this is not a very specific definition, presumably this means Eversource's current rates; in 2020 WUS paid Pegasus $.063/kwh compared to an annual average of $.267/kwh to Eversource/Dynergy. These terms are excellent and typical PPAs from these years offered only a 10 - 20% savings.

(Note: there is a discrepancy in the terms described in the BlueSel letter and the Pegasus contract. The BlueSel letter says the rate starts at a 55% discount for the first 10 years then goes to a 90% discount while the Pegasus contract only states 70% discount with no time qualification. The Pegasus contract is dated later than the BlueSel letter and presumably is the governing document.)

Electricity production in 2020 was lower than it has been in the past and that may indicate a problem (see Electricity Figure 1). The Pegasus contract states that the system was expected to produce 20,321 kwh in its first year of operation and according to the SolRen monitoring system it actually produced over 21,000 kwh from 2012 - 2014, then dropped to 20,090 in 2015, and has never returned to close to 21,000. In 2020, it produced 19,580 kwh, or 11% less than 2013. While solar panels produce .5% less electricity each year, the system should still be producing over 21,000 kwh.

The drop in production in 2015 is suspicious and can't be explained by the main factors that usually impact production: changes in shading (which is not an issue at WUS) and weather fluctuations (the amount of cloud cover and snow in a given year). During the term of the PPA, Pegasus is responsible for repair and maintenance and you should ask them to investigate whether one or more panels or microinverters have malfunctioned, which they may be able to do using their online access to the monitoring system.

The contract gives WUS the option to buy the system at "fair market value" at year 12 of operation, which will occur in March 2024. Factors to be considered at that time include:

- The "fair market value" offered: since WUS was one of the first houses of worship to install solar, MassIPL has not seen a system reach this point yet. In conversations with our solar partners, they say there is no standard methodology for determining this value. It is likely to be based on either the net present value of the electricity produced over the next 13 years (the production warranty period) or what a new system of this size would cost today depreciated for 12 years. Since Pegasus has likely fully depreciated the cost of the system (ie, it has zero value on their books), it is likely negotiable.
- The contract notes a $22,900 "deposit" but doesn't describe the accounting treatment. No doubt Pegasus used this money to decrease the amount of capital they used for the project. It would be fair to argue that this amounted to a partial purchase of the panels, so should be deducted from the original cost before calculating the fair market value.
- Degradation of performance: if it is not due to a simple, easily diagnosable issue, it might indicate the panels are degrading faster than would be expected. This would be a factor against purchasing the system or could be used to negotiate a lower value.

Note that at this time there is no secondary market to sell old panels and recycling of old solar panels is rare, though it is a growing topic in the solar community and many expect recycling to become available in the coming years.

Should WUS opt to consider a new system, MassIPL can help. We have helped 50 HOWs install solar in the last 10 years. MassIPL has 3 partners for solar panels:

- 621 Energy (http://www.621energy.com/) has been MIPL's solar partner for 4 years and offers a power purchase agreement to make solar affordable for HOWs. Contact Bob Clarke, clarker@621energy.com
- Resonant Energy (http://www.resonant.energy/), a partner for 5 years, offers a range of programs to help HOWs install solar, including its Interfaith Community Solar program. Contact Macy Zander, macy@resonant.energy
- Energy Sage (www.energysage.com/mipl) is an online site where you post the HOW's address and some information about its energy use, then multiple solar companies will evaluate and provide proposals.

When you install solar panels using one of these partners, they make a donation to support MassIPL. MassIPL can assist you in this process.

ELECTRICITY Photos

Photo E-1 – Electrical service panels occupy a large section of wall in the boiler room

Photo E-2 – MassSave installed a standard “Edison” shape light bulb in this fixture. Other styles that are “vintage” or candle shaped are available that may be more appropriate for this fixture.

Photo E-3 – This recessed LED light is outside the offices.

Photo E-4 – Small recessed LED lights can be seen in the ceiling over the bay window in Michelsen.

Photo E-5 – And LED surface-mount fixture in a hallway of the RE Wing.

Photo E-6 – This exit sign in the RE Wing appears to have an LED light bar inside it. Exit signs in Metcalf Hall may still have incandescent lighting and replacement LEDs should be installed.

Electricity Photos (continued)

Photo E-7 – These lighting dimmers used to operate the Sanctuary lighting but were not replaced when lights were upgraded to LED, and are unlikely to be compatible.

Photo E-10 – This label for the Metcalf refrigerator shows it was manufactured in 2009. It is reasonably efficient but when it is time for a replacement, be sure to buy an Energy Star top-rated model.

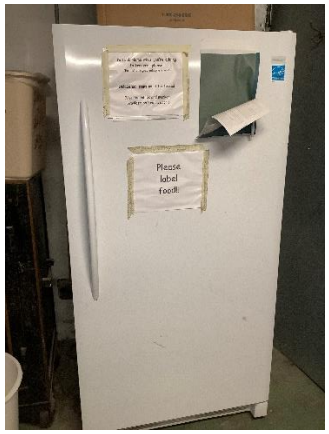


Photo E-8 – This freezer in the boiler room displays an Energy Star label so it is very energy efficient.

Photo E-11 – The small beverage fridge in the Symmes kitchenette was empty but set at such a low temperature that ice formed on the coils. Adjust to a warmer setting. Or turn it off until in-person events resume.

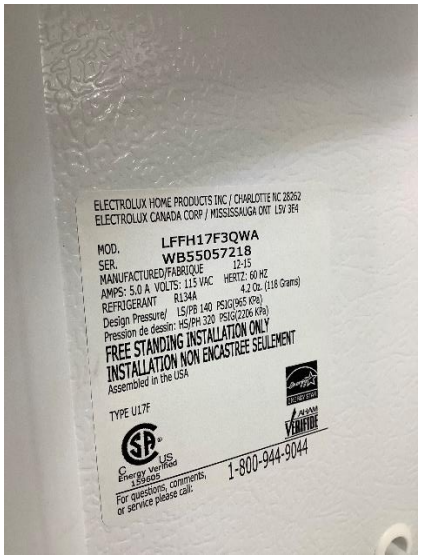


Photo E-9 – The label for the freezer shows it was manufactured in 2015. It has many years of efficient life left!

Electricity Photos (continued)

Photo E-12 – This commercial dishwasher in the Metcalf Kitchen is of unknown age and efficiency. MassSave offers rebates to upgrade this type of equipment.

Photo E-13 – The label for the Metcalf dishwasher shows model number.

Photo E-14 – This undercounter dishwasher in the Symmes kitchenette is also a commercial model. Age is unknown but may be from the mid-1990's.

Photo E-15 – The Symmes kitchenette dishwasher is Hobart model LX30H ML 104354.

Photo E-16 -- The range in the Metcalf kitchen is old. MassSave incentives will help replace this with a modern, pilotless range. Or consider upgrading to electric induction.

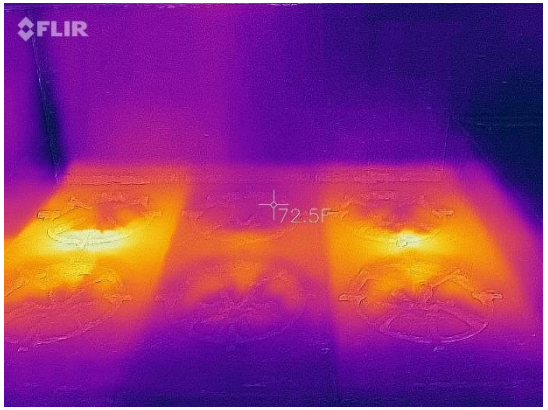
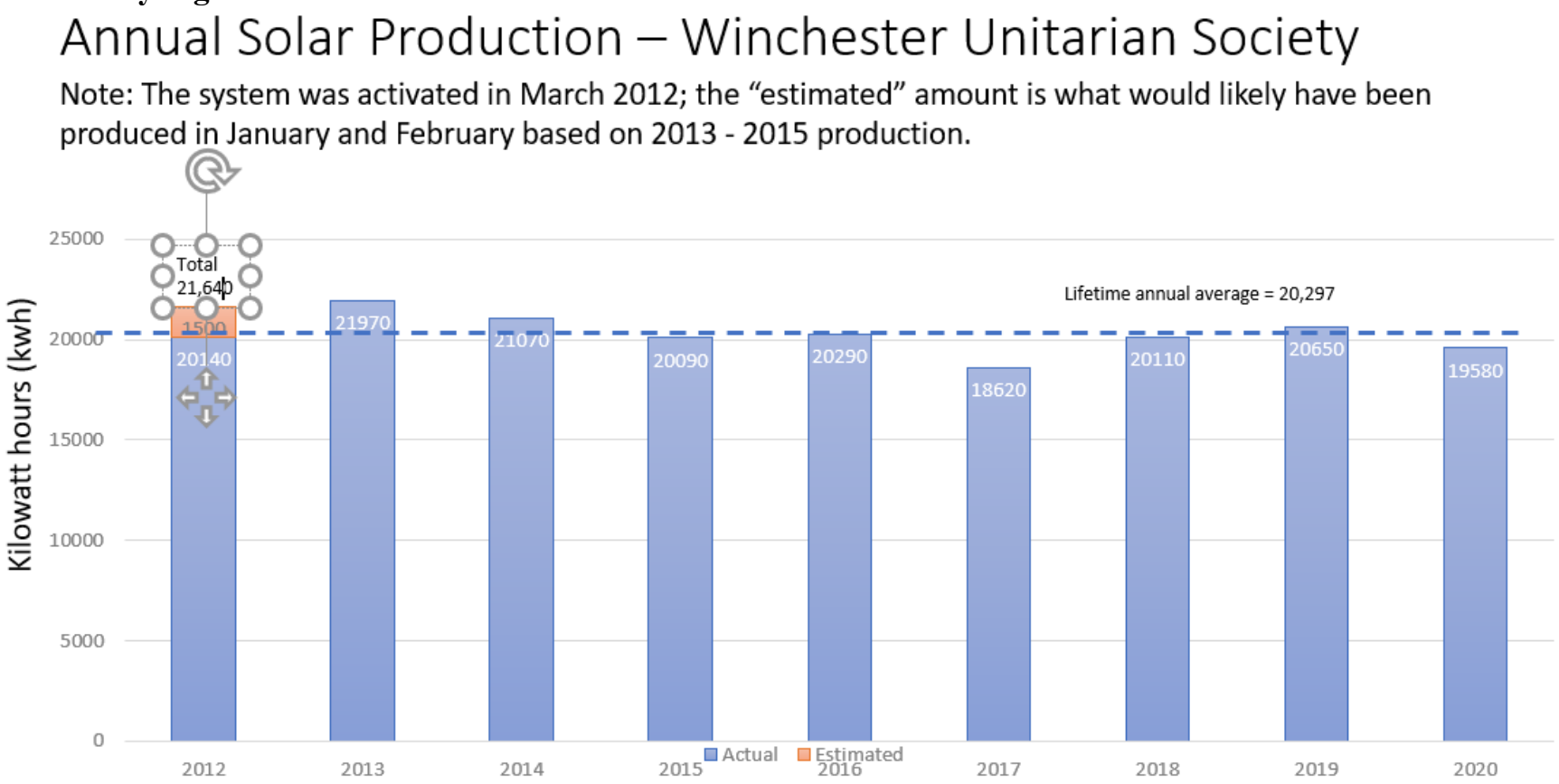


Photo E-17 – This infrared photo of the Metcalf kitchen range shows the pilot lights are burning 24 x 7.

. **Electricity Figure 1**



Note that in 2012 – 2014, production was over 21,000 kwh, then dropped to 20,000 in 2015 and has stayed there. It is possible that one or more panels or microinverters has malfunctioned. Pegasus is responsible for the repair and maintenance of the system and should perform a system check.

ELECTRICITY
PHOTOS (continued

Photo E18 — The solar panels use Enphase micro inverters to convert the DC electricity generated by the panels into AC current usable by light, appliances, etc.

Photo E19 — The disconnect switch for the solar panels is located in the corner where the Metcalf Hall connects to the Office section

BUILDING ENVELOPE

"Building envelope" is a term energy efficiency professionals use to refer to the role walls, windows, insulation, and other physical characteristics play in determining energy use, cost, and carbon footprint. A "tight" envelope prevents the air warmed in the winter or cooled in the summer from leaking out of the building and a well-insulated envelope prevents heat from being transmitted through the walls and roof.

There are two major construction types present: the stone-and-slate-roof portion for the church and offices (original construction in 1898, with sections added in the 1920's) and a stucco, flat roof addition of the Religious Education (RE) Wing constructed in the 1950s with additional work in the 1990's. Both offer opportunities for improving the thermal performance of the building. The presence of icicles and ice dams in various locations of the building (see Photos BE-1 through BE-3) indicate lack of insulation and heat escaping to melt snow on the roof, not surprising in a building of this age.

Have you created heating/cooling zones that match use patterns? **No**

There are two ways to think of zones: the physical property of the areas served by a single thermostat, and the usage patterns that determine which rooms require heat at particular times. Ideally, these should align so that only the spaces being used are heated or cooled.

The use patterns of HOWs are highly variable, even for buildings that otherwise are essentially identical. Often, only the offices or a meeting room are being used. If the current zones of a HOW do not match use patterns, money and energy are being wasted. Updating zones can be more or less complicated (ergo expensive) depending on the type of heating or cooling system and its associated distribution and controls.

Evaluation

The *Space Use* table in Appendix B presents WUS's current pattern of use and the recently completed zone map.
There are five zones in the building as outlined in this chart, plus some rooms are associated with branches of the steam distribution piping that lead to inefficiency:

#	Location	Condition	Rooms served	Evaluation
1	Sanctuary	Time set correctly	Sanctuary, Foyer, part of Symmes	The rooms in this zone are generally used at the same times
2	Office	Time set correctly	Senior minister's office, church office, Parlor, part of Symmes, Metcalf Kitchen, Pantry	The Parlor and Offices are used at significantly different times; Symmes could be removed from this zone.
3	Metcalf Hall	Time was 45 minutes ahead of actual time	Metcalf Hall, pantry, and part of Metcalf Kitchen	This is a compact, logical zone. Potentially the Kitchen and Pantry could be a separate zone.
4	RE Wing Main Floor	Time set correctly	RE Wing main and upper floors, Wallace Room, and part of Michelsen	The Wallace Room and Michelsen are used much less than the RE Wing, making this an inefficient zone.
5	Meyer Chapel	Time set correctly	Meyer Chapel, Youth Room, part of Michelsen, part of Metcalf Kitchen	These rooms are all used at significantly different times, and are located at some distance from each other indicating opportunity to split them into different zones, possibly with heat pumps.
	Uncontrolled areas		WC in Senior Minister office, part of Michelsen, part of Parlor, part of Symmes, Symmes kitchenette, part of Winsor, accessible bathroom	These areas are on when any zone in the building calls for heat though their occupancy is highly variable.

The zones reflect the nature of additions and changes to the heating system over time, with a number of rooms in the inefficient condition of being served by multiple zones, thus being heated at times when they are not used. Chuck Khuen is continuing to investigate the distribution system and potential solutions to these inefficiencies. Pending the findings, look for the lowest cost potential solution, including testing shutting off the heat from one of the zones to see if there is sufficient heat from the primary zone without it. At this time, MassIPL suggests:

- The Parlor: Served by one uncontrolled branch of the heating system and the Office Zone. Unless there is a way to add controls to the uncontrolled branch, disconnect that heat and leave this on the Office Zone.
- Symmes: The Sanctuary is the primary zone, so shut off those portions that connect to the Office zone. Monitor the water pipes in the kitchenette to ensure they don't run the risk of freezing (though they are on an interior wall so this shouldn't be an issue).
- Michelsen: the RE Wing is the primary zone, so shut off the radiators connected to the uncontrolled areas.
- Metcalf Kitchen: Metcalf Hall is the primary zone, so shut off the radiators connected to the uncontrolled areas.
- Winsor. During the preparation of this report, a new controller and thermostat was added to the forced hot air units serving this room, so the radiators connected to the Sanctuary zone should be shut off.

Another option may be to add some of these rooms to the heat pump that MassIPL recommends to replace the air conditioning equipment serving the office (see page 38).

Are thermostats set to temperatures compatible with use and time? Yes

One of the benefits of living in a computer age is that thermostats can be programmed and controlled from a distance. *Programmable thermostats* automatically adjust to the desired temperature for the desired time period. The multiple time settings (typically 4 settings per day) permit scheduling of space conditioning (heat or cool) when and only when needed. Thermostats must be periodically checked to see that the programmed times match current usage of the room. With *Wi-Fi* based thermostats, this check can be done remotely, via a *SmartPhone*. This also enables resetting thermostats whenever a significant change to the use of the building occurs, such as a community group beginning/stopping holding meetings, adding a new service, changing times when the office is open, unexpected use or cancelations and so on. *Programmable thermostats* with an ***adaptive recovery*** element anticipate how long it will take to reach the desired temperature and start the system in just the right lead time. In short, the thermostat "remembers" what humans often forget.

Evaluation

As noted above, the *Space Use* table in Appendix B presents Winchester Unitarian Society's current pattern of use.

Also as noted in the table above, we did not check the timing of the thermostats relative to the use times. We did notice the thermostat in Metcalf Hall was not set to the correct time. The *Energy Manager* should check and set thermostats at least four times per year: at the beginning and end of the heating season, and the changes between standard and Daylight Savings Time. WUS is considering upgrading thermostats to Wi-Fi enabled smart thermostats which would enable better control and remote programming; this is an upgrade well worth considering and should qualify for MassSave incentive money.

Do you keep doors closed between heating and cooling zones? Yes

Having the right zoning pattern won't help much if the doors between the zones are not kept closed. An open door simply means that the heating or cooling equipment has to work harder, as it is providing space conditioning not only for the desired zone but also for whatever spaces to which doors are open. Encourage staff and congregation leaders that if they see an open door, they should close it; signs on doors between zones that say "Please keep this door closed" are a helpful reminder.

Evaluation
Generally, doors between zones were observed to be closed. In addition, the Vestibule, the entry to the Metcalf kitchen, the entry near the Minister's office, and the entry to the RE Wing all have entry halls that serve to buffer heat loss when doors to the outside are opened.

Have you sealed areas of air infiltration? No

Just as open doors between zones are a cause of inefficiency, areas of air infiltration (aka "holes") cause inefficiency. The most common areas of infiltration are doors or windows that have gaps around the edges, places where pipes or electric wires enter the building, electric sockets and switches that are on outside walls, and along the sill plate (where the top of the foundation meets the framing of the walls). It is rather amazing how these small areas can add up to a large hole. The EPA estimates they can add up to as much space as if you left a window wide open! Sealing these areas can be a project for a workday with simple materials you can buy at any hardware store or home center: door and window weather stripping kits, socket and outlet insulation, caulk, cans of spray foam. Sealing these areas can also keep out mice and insects.

Evaluation
There are several opportunities to decrease air infiltration at doors:

- "Snowblower room" This room has been the site of pipes freezing and in the past a space heater was used as a preventative; now the pipes are insulated and have thermostatically controlled heat tape. The heat loss in these rooms is primarily through 2 doors and can be improved. The door to the outside has a large gap at the bottom which is easily blocked with weatherstripping or a "draft blocker" Applying 2 inches of rigid foam to the interior would add R-12 insulation (see Photo BE-4). Similarly there is a door that is no longer used and now is a site of a vent exiting the building; rigid foam can be cut around the vent and applied to the door with adhesive (see Photo BE 5).
- Metcalf Hall emergency exit (see Photo BE-6). As this infrared photo shows (see Photo BE-7), there is significant heat loss through and around this door. Weatherstripping is an inexpensive short-term fix but longer term a replacement should be planned.
- Music Director door (see Photo BE-9): The door is cracked allowing a direct path for air to leave the building (see Photo BE-8). In addition, cobwebs indicate there is airflow around the door. Weatherstripping the door and caulking the crack is a short-term fix, but this is a candidate for a replacement door.

The main entry doors are wood and need improved weatherstripping. (See Photo BE-10 and BE-11.) Similarly the main door to the RE Wing shows significant gaps where new weatherstripping should be installed (see Photo BE-12) though since there is a vestibule, any heat

loss is buffered (see Photo BE-13). Monitor at the start of winter and summer seasons to ensure that the weatherstripping continues to function effectively.

Are your walls, ceiling, floors insulated? No

Even if there are no gaps for air infiltration, building materials will conduct heat out and cold in at wintertime, and the opposite in summer. Because heat rises, insulating ceilings and under roofs is most effective. Well-insulated space retains its desired temperature and takes a shorter time to achieve this temperature. The exterior portions of a building (side, top, bottom) are the key areas for insulation. Buildings with pitched roofs and little-used attics are best served by having the floor of the attic insulated, as it is the "exterior" of the occupied space. Similarly the ceiling of a little-used basement is the "exterior" of the occupied space. Older buildings, especially 19th/early 20th century with stone walls (as WUS is), present particular challenges for wall insulation. The Energy Star web site has good information on insulation:
http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_seal_insulate

Evaluation

In the Sanctuary, it appears that there may well be no insulation between the interior ceiling paneling and the roof. It would be possible to add rigid foam on the interior, with new paneling or sheetrock on top of that, though this is a major project. The Parlor has a drop ceiling with a hatch to access the area so insulation should be a practical action (see Photo BE-14). Michelsen has recessed ceiling lights which may provide access to blow in insulation, especially at the bay window. The RE Director's office doesn't appear to have any way to easily access the space above their ceiling, but an insulation company may be able to do some air sealing or blow in insulation. Alternatively, should the slate roof need replacement at some point, exterior rigid foam insulation could be added before new slates or other roofing materials were installed.

The roof of the RE Wing has only 2 inches of fiberglass insulation that is at best R-6 insulation value; to illustrate how insufficient this is, current code requires R-49. Further, it is old and not installed well so likely has even lower R value. There is significant space between the ceiling and the roof deck to blow in additional insulation (see Photo BE – 15).

It isn't possible to know what insulation is in the walls of most of the building. Interior walls are plaster while the exterior construction is stone, with the overall wall thickness suggesting there is little room for insulation (see Photo BE-16). Should there at any time be a need for a major renovation that would involve opening up these types of walls, the reconstruction should prioritize adding insulation.

The RE Wing is cinderblock construction with exterior stucco facing and large curtain walls of glass on each side (see Photo BE – 17) the walls in the classrooms appear to be studded out in sections and there is likely little or no insulation. Improving the thermal performance of this part of the building would best be accomplished through a significant retrofit that would address the ceiling insulation described above, apply exterior insulation with new stucco facing, and replace most of the windows (see the discussion of windows in the next section). With this kind of retrofit, it would then be likely you could take the RE Wing off the steam heating system and install heat pumps.
The south wall of the office section has exterior stucco and could receive the same exterior insulation treatment as the RE Wing.

The roofing membrane of the RE Wing (which notes in the solar panel proposal state was installed in 2000) is white, which reflects summer heat, helping to cool the building.

As part of a MassSave audit, have all these suggestions evaluated; the rebates and incentives for this work typically pay at least 75% of the cost of standard air sealing, weather stripping, and insulation projects. For the retrofit of the RE Wing, WUS may be eligible for new programs for renovations https://www.masssave.com/en/saving/business-rebates/new-buildings-and-major-renovations : "Path 3 Whole Buildings Streamlined" or "Path 4: Systems." The program is new and there is limited detail available but will become available in the near future.

Do you have high efficiency windows? Interior storms? Sun screens? Yes and No

High efficiency windows (sometimes referred to as *thermopane*) serve to provide additional insulation. Some are *fixed* while others are *operable*. Operable windows with cranks can shut tightly but may need weatherstripping if they are old. Older windows (typically single pane) that slide up-and-down typically have counterweights, with a cord or chain moving over a wheel at the top, with the counterweight in a void on the side of the window. This void needs to be filled with insulation when the window is upgraded to thermopane and a vinyl track installed for up-and-down movement.

In general, windows are considered to have the lowest return (measured in either financial terms or carbon reduction) of common energy efficiency projects as long as the windows are in acceptable condition. However, if the frames have deteriorated there is likely significant air infiltration that loses more energy than the window itself. In this case, replacement is a necessary investment and the incremental cost to go from double pane to triple pane is a relatively minor part of the overall cost but results in double or more insulation value.

Interior storms also called *window inserts* add another layer of physical protection to block drafts and create an additional barrier to heat loss. Interior "storm" windows serve to make the single-pane windows similar to *thermopane* glazing, reducing heat loss in winter and heat gain in summer. This also improves occupant comfort. Stained glass windows are almost always single pane and allow significant air infiltration around the leading and sections that may be operable. There are a number of companies that make window inserts which cost $100 - $150 for a typical size window. One noteworthy provider is Skylarc Innovations' Windowtherm panels www.skylarcinnovations.com which has been tested to increase window insulation value by R-2. For more information, see MassIPL's *EES Brief* on *Interior Storms.*

In the summer, consider window inserts that use a film that blocks the sun's heat from entering the building. Similarly, for windows that have screens, consider installing *sun screens* that block up to 80% of the heat from sun exposure, keeping the room cooler without the use of air conditioning. For both window inserts and sun screens, rooms that face south and west – especially frequently-used rooms like offices – are the best candidates.

Evaluation

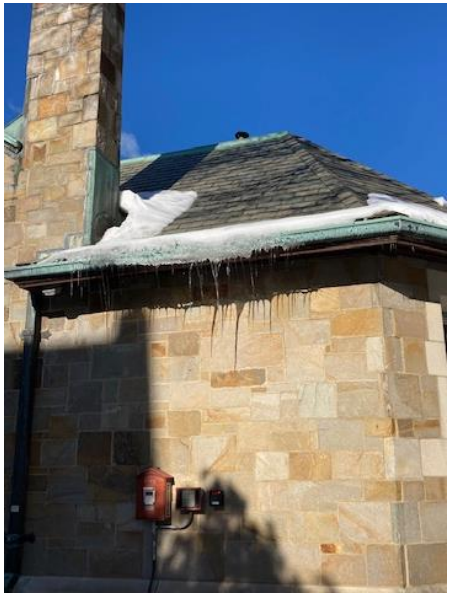
Many of the windows in the building are single pane casement windows with leaded glass: Metcalf Hall and Kitchen, the offices, the Parlor and Michelsen (See photo BE-18). Staff have built window inserts in the offices (see Photo BE-19) and RE Director office, but windows in the Parlor, Metcalf Kitchen, Metcalf Hall, and other areas don't have them but could easily accommodate them (see Photo BE-20). The south-facing windows in the offices are candidates for summer window inserts with a reflective film (that would decrease the heat gain from the sun) or sun-blocking screens that would lower the need for air conditioning.

There is considerable glass along the walls on both sides of the RE Wing that are large single-pane picture windows with operable awning windows on the bottom (see Photo BE-20); these windows have aluminum frames which are very efficient conductors of heat out of the building (see Photo BE-21). Because they make up 50% or more of the wall area of the main and upper floors, the walls have a very low insulation value. Typical Thermopane windows with wood frames such as those in the 1990's addition on the south end of the RE Wing (see Photo B-22) rate at R-3 which results in considerably less heat loss (see Photo BE - 23). Triple pane windows can achieve R-8 and "European style" windows with tilt-open mechanisms minimize infiltration. Ideally, window replacement would be part of a larger energy performance upgrade on the RE Wing described separately.

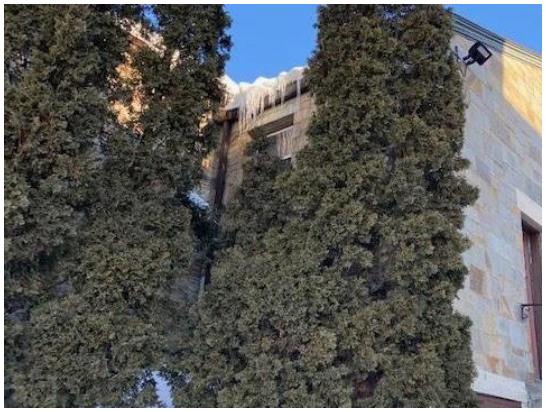
Two other areas show appropriate use of exterior storms that blend well and don't detract from building appearance: the accessible bathroom (see Photo B-24) and the Winsor windows (three windows have exterior storms in Photo B-25 while one window currently does not but it could be added – Photo B-26).

BUILDING ENVELOPE Photos

BE1 — Icicles and ice dams outside the accessible bathroom indicate little insulation in the roof.



BE2 — More icicles at the corner of the Parlor.



BE3 —More icicles over the Music Director's office

BE4 — Exterior door in the "snowblower room" needs weather stripping and 2-inch poly-iso rigid insulation applied. Water pipes in this room need a heat tape and these improvements may eliminate it.

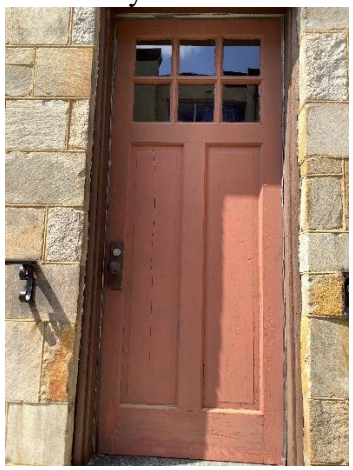
BE5 — A former exterior door, now used as bathroom vent; 2-inch poly-iso rigid insulation applied.

Building Envelope Photos (continued)

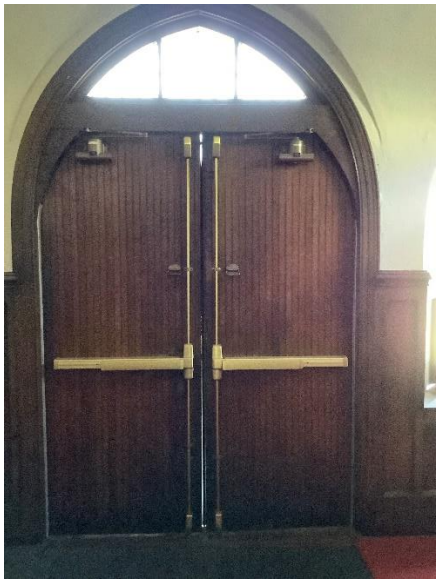
BE-6 – The emergency exit door in Metcalf Hall needs improved weatherstripping…

BE-7 — This infrared photo shows 46 degrees at the edge of the Metcalf emergency exit door

BE-8 -- The exterior door to the music director's office has a crack that allows air directly in.



BE-9 The music director door is a candidate for replacement.



BE-10 – The front entry door shows a gap between the two doors.

BE-11 – The front entry doors would also benefit from improved weatherstripping along the door jambs.

Building Envelope Photos (continued)

BE- 12 – The main door to the RE Wing has old weatherstripping that needs to be replaced, especially the gap between the two doors.

BE-13 – The RE wing has a vestibule that buffers heat loss between Metcalf Hall and the exterior

BE-14 – The Parlor has a hatch allowing access to space above the dropped ceiling which should enable adding insulation

.

BE 15 -- Insulation in the ceiling of the RE Wing, viewed through a hatch in one of the classrooms. This is insufficient but could be supplemented with blown-in insulation.

BE 16 – The view out this window in the Parlor shows wall construction: thick stone exterior, likely with little insulation between it and the interior wall.

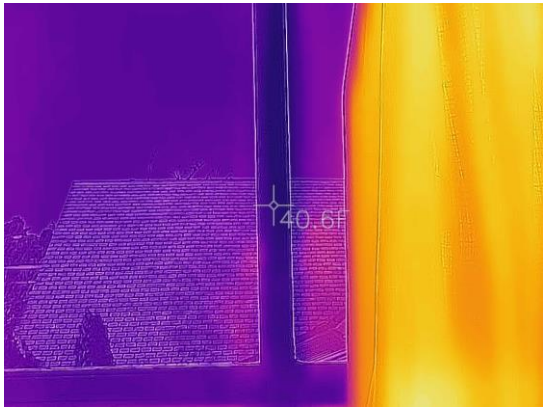
BE 17-- Exterior of the RE Wing. Large single pane windows with aluminum frames have poor thermal performance. The wall is stucco over cinderblock with no insulation.

Building Envelope Photos (continued)

BE-18 -- This window in Metcalf Hall is the dominant window type: casement, single pane, leaded glass. Inefficient due to air infiltration and low R value.

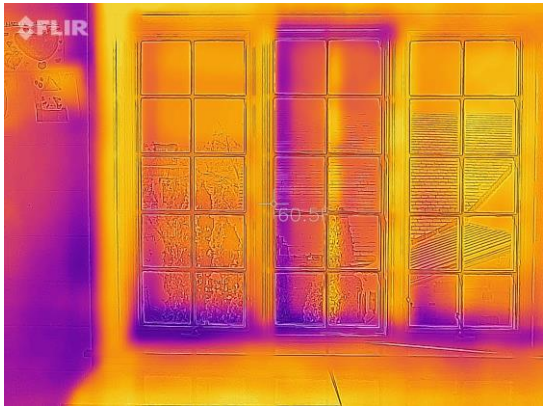
BE-19 – Staff have build window inserts for these office windows to improve comfort.

BE-20-- Single pane window with aluminum frame in RE classroom.



BE-21 -- Infrared photo shows poor thermal performance of single pane aluminum frame windows.

BE-22 – A newer window in the 1990's addition to the RE Wing is thermopane with simulated divided lites.



BE-23 -- Infrared photo of the 1990s windows show better thermal performance with some need to replace weatherstripping at edges.

Building Envelope Photos (continued)

BE-24 – Exterior storm windows at the accessible bathroom aren't noticeable.

BE-25 – Exterior storms on windows into Winsor.

BE-26 The window to the right does not have an exterior storm, but one could be added. The window to the right serves as a vent.

BE-27 – Windows are a significant element contributing to the appearance of a building. The windows in the 1990's RE Wing elevator addition are highly compatible with the windows in the offices

HEATING, COOLING AND WATER

Heating (and if used cooling) is likely the biggest user of energy at your HOW, and thus both the largest contributor to climate change and a significant expense. In looking at this equipment, three areas are evaluated:

- *Generation* (the equipment that heats or cools air or water)
- *Distribution* (the system that takes the heated air or water to the spaces where it is needed)
- *Controls* (mechanisms that control generation and distribution).

Each of these offers opportunities to decrease your energy use and carbon footprint. When it comes time to replace generation equipment, you should prioritize energy efficiency and lowest carbon emissions in choosing new equipment. That will likely mean upgrading to *heat pumps.* The MassSave program is prioritizing heat pumps as a replacement for fossil fuel-fired equipment and the Baker Administration's 2050 Decarbonization Roadmap says this:

- "...in order to achieve Net Zero, the use of gas for building heat must start to decline in the near term."
- "...electrification and efficiency strategies rely on infrequent opportunities to change out heating, ventilation, and air conditioning (HVAC) equipment, such as equipment end-of-life or major renovation. Leveraging these opportunities early is essential for keeping costs low."

Heating and cooling equipment typically last between 15 - 30 years and so it is likely every piece of equipment operating today will be replaced at least once between now and 2050. If your equipment is more than halfway through its useful life, you should begin educating yourself about new technologies, begin planning for its replacement, and setting aside money to pay for it. In addition, MassIPL believes it is likely there will be new programs and incentives developed in the next few years to encourage Commonwealth residents to replace fossil fuel fired equipment. Learning and planning now will mean you will be in a good position to take advantage of new programs as soon as they are available.

Though often taken for granted, water use can be significant and costly. This is especially true for Winchester Unitarian Society due to the use of the RE Wing by Winchester Cooperative Nursery School and being hosts for a variety of other users. In these instances, use of sinks and toilets draws considerable water. It also increases the demand of water supplies, a matter of increasing concern.

Is your boiler or furnace 95%+ efficient? No

Boilers heat water, creating hot water or steam. Furnaces create hot air. (Note that some boilers also create hot air by sending hot water or steam to *fan coil units*, which have a fan blow air over the hot coils to send heated air to spaces.) Hot water boilers are able to heat the water to varying temperatures (typically a maximum of 180°), depending on need. Steam boilers always heat to 212°. Thus intrinsically hot water boilers are more efficient than steam. Furnaces are also able to heat to different temperatures, though not with the precision of hot water boilers. Gas can be used in boilers or furnaces with very high efficiency (95%+), while oil efficiency caps at the mid-80% range. For more information, see MassIPL's *Everyday Environmental Stewardship* brief on *Heat Generation*.

In order to achieve net zero carbon emission by 2050, we must transition away from fossil-fuel fired heating equipment to the maximum extent practical. Any time an existing fossil fuel heating system reaches the end of its useful life, it should be replaced by equipment that doesn't

emit carbon. The leading technology today is a *heat pump*. A heat pump may sound like an exotic new technology, but is already widely used in Europe and Asia, and increasingly in the US. Simply put, a heat pump moves heat from one place to another. In fact, a refrigerator is a type of heat pump that cools food by taking the heat from the inside and blowing it outside-- you feel the heat coming out from under the refrigerator when it is working. Air conditioners work by a similar principle, using an electrically-driven compressor to cool occupied spaces while blowing hot air outside. So, by reversing the process, occupied spaces can be heated. The equipment for doing both heating and cooling is called a ***heat pump***. Because New England winters are cold, install a *cold climate heat pump* which will remain efficient down to zero degrees Fahrenheit or lower. Because heat pumps operate on electricity, their carbon footprint will decrease as more wind and solar power is added to the electric grid; if you can install solar panels, your heat pumps may have zero carbon emissions. *See MassIPL's EES Brief* on *Heat Pumps.*

Evaluation

WUS has a complicated heating system with multiple generations of equipment and components that have been added on over the years.

- Outdoor fresh air ducts that appear to have been part of the original 1898 design. These have been blocked off to avoid losing heat through them in the winter.
- Convection hot air system for the Sanctuary and Symmes Hall: steam radiators allowing heat to rise through floor grates
- Forced hot air systems for Winsor and Meyer Chapel: a steam radiator inside ducts with a fan to blow hot air into these rooms
- Steam radiators for the bulk of the building
- Economizer units for Metcalf Hall and Meyer Chapel primarily used to address humidity and manage CO2 levels during teams of peak usage.

The primary heat for WUS is generated by a gas-fired steam boiler by Weil-McLain with 1989 MBTU/hour output installed in 2000 (see Photo H-1). It is well maintained and is operating at 82.9% efficiency, good for this type of equipment (see Photo H-2); it is on a timer that shuts off the boiler when not needed (see Photo H-3). But steam is inherently inefficient since it always heats water to 212 degrees and complex requiring significantly more maintenance than hydronic (aka hot water) or furnaces. The multiple systems further increase the complexity and maintenance effort and cost.

The boiler is about 2/3s the way through its expected life. An explicit element of the state's goal to achieve net zero carbon emissions by 2050 is to eliminate the use of fossil fuels in heating, so simply installing a new steam boiler with similar capacity will be discouraged. As the state implements the new legislation, we expect to see new programs of incentives, rebates, and technical assistance in the next couple of years.

Given the likelihood of an extensive replacement, you will have the opportunity to reevaluate the entire HVAC system to streamline and simplify it, reduce required maintenance, improve the zone issues discussed earlier, increase energy efficiency, and decrease carbon emissions. This will take careful planning by a mechanical engineer or building science consultant such as New Ecology www.newecology.org or Building Science Corporation www.buildingscience.com . Given the timeframe in houses of worship to plan, raise money, and implement projects of this size, it is not too early to begin planning for a new system. New MassSave incentive may pay part of their design and consulting fees.

The Sanctuary is the one space that may be difficult to heat with heat pumps due to its size, lack of roof insulation, and 3 large stained glass windows that likely allow significant air infiltration. Should this require a new fossil-fuel fired system, pay careful attention to the design and equipment to ensure the highest efficiency and lowest use of fuel. For example, you would likely install high efficiency (95% - 97%) hydronic boilers that modulate the firing rate down to 10% of input to precisely match heating load requirements for greater efficiency and less cycling. The boilers would also be controlled with an "outdoor reset", so that temperatures modulate in relation to need based on how cold it is outside. (See controls below.) We often suggest two smaller residential scale boilers (instead of a single commercial scale boiler) that are phased to come on in sequence, and cycle the sequence so that each is operated regularly. Residential equipment is generally less expensive and easier to maintain than commercial equipment and this configuration would provide maximum control and efficiency.

Is your domestic hot water heater 95%+ efficient? No

Standard domestic hot water ("DHW") vertical tanks are not very efficient (65±%) even when DHW is needed; they are 0% efficient when DHW is not needed. A HOW has relatively little use for DHW, both as to time and as to volume. Virtually no HOW's have showers, which is the reason that DHW tanks with large volume capacity (typically 40 gallons) were invented. HOWs use DHW at sinks, and in dishwashers, so the volume needed is much less. When used in dishwashers (whether residential or commercial), the DHW from the source (typically at the 110° level) is heated to an even higher temperature by the dishwasher.

A more energy efficient and lower carbon alternative is an on-demand DHW system which heats water only when the tap is turned on, eliminating the waste of heated water in a tank cooling because no one is using it. This cuts energy use by 30 - 40%. On-demand DHW systems save more money because they typically last 20 years, compared to tanks which often need to be replaced in about 10 years.

Whatever type of hot water system you have, be sure the temperature is set to no more than 120˚, both for energy saving and to prevent scalding. For more information, see MassIPL's *Everyday Environmental Stewardship* brief on *Domestic Hot Water*.

Evaluation

WUS has a single hot water tank, a gas-fired Ruud 67 gallon with a pilot light (see Photo H-4 and H-5). Its age is unknown though from the style of the logo it appears to be quite old. It is located in the boiler room, under the Symmes Room, far away from the kitchen, which is likely the point of most use; only the Symmes kitchenette and accessible bathroom are near and their hot water use is likely minimal.

The DHW heater is past the expected life of 10 years. This is a prime candidate to be replaced with an on-demand hot water heater, ideally relocated to a location more central to the building, perhaps the Metcalf Kitchen, and thus shorter runs to bathrooms and the kitchen. Given the low amount of hot water used, an electric on-demand water heater should be the first option considered. It may make sense to install several smaller electric on-demand units, each right at the point of use.

Is your air conditioning SEER 14+ efficient? No

If you have air conditioning (AC), it can be a significant use of electricity in summer. Thus it is essential to have highly efficient equipment that is properly sized for the space. A new technology that is being used in many HOWs via retrofit is *heat pump*. This technology permits targeted cooling (and heating) of specific spaces. The typical first location for this equipment is offices. Others location include spaces used in summer for meetings and worship. For more information, see MassIPL's *Everyday Environmental Stewardship* brief on heat pumps.

Evaluation

The office space is the only space that is air conditioned. There is a 2-ton SEER 13 Trane 13XLi compressor unit outdoors manufactured in 2003 that uses R-410A refrigerant (see Photo H-6, H-7) The unit shows signs of age: severe rust on the fan, broken grates. A/C compressors typically have a useful life of 15 - 20 years, so this unit is due for replacement. New equipment will start at SEER 14 and go up to 22 (higher SEER numbers indicate higher efficiency).

Rather than just replace this with another A/C only unit, this is a perfect candidate for a heat pump replacement. This would allow you to take the offices off the steam boiler and heat and cool this section of the building with clean electricity. MassSave incentives typically offset the higher cost for new heat pumps compared to an A/C only unit so the heat pump likely will cost no more than the A/C replacement.

There is an access door in the Senior Minister's office which appears to allow access to the air handler and ductwork (see Photo H-8; to avoid disturbing the office, we did not investigate this thoroughly). We were able to see some flex duct that distributes the air from the air handler to the vents; because flex is a continuous tube, there is likely less air leakage than sheet metal ducts typically experience. Likely the preferred installation scenario for the heat pump would be to remove the air handler and run refrigerant lines to in-space distribution equipment; Mitsubishi and other manufacturers offer floor-mount units that occupy roughly the same space as an existing steam radiator (see Photo H-9). If preferred, it may be possible to install a new air handler compatible with the new outdoor unit, and then distribute the air through the existing ductwork. You should discuss both options with your HVAC contractor.

MassIPL recommends WUS undertake this project immediately.

Do you have controls that optimize energy efficiency? Yes No

Even if generation equipment is highly efficient, energy can be wasted if controls don't match heating and cooling to the actual need. If rooms are heated or cooled when no one is there, it is wasteful. The most familiar control is the ***thermostat***. (See the discussion on thermostats in the Building Envelope section.) Hydronic heating systems should have an ***outdoor reset control***. It adjusts the water temperature based on how cold it is outside. For example, in deep winter it would set the boiler to heat water as high as 180° but in fall and spring only to 110°>140°. Thus the amount of fuel used to reach a desired comfort level matches need. A ***variable speed pump*** adjusts the volume of heated water sent to the use locations. If heated water is returning at a temperature not much lower than it was sent out, the spend of delivery can be reduced so

that the heat is transferred in the use spaces. Again, this reduces fuel use, and therefore cost. An ***energy management system*** (*EMS*) is a computerized system that centrally manages all thermostats, logging in remotely to change settings rather than setting each individually *in situ*. These systems also provide detailed information about energy use in the building to help manage use and cost even more closely.

Evaluation

The zones and their related controllers and thermostats have been thoroughly discussed in separate sections. At this time, WUS is considering upgrading all thermostats to Wi-Fi enabled smart models for better control. This is an excellent option to evaluate and may be eligible for MassSave rebates and incentives.

Are heat/AC means of delivery efficient? Yes

Getting space conditioning (water, steam, air) to the use location is the first delivery consideration. Uninsulated pipes and poorly-sealed ducts waste 10 - 30% before reaching the use space. Improving insulation and reducing air leakage in ducts is often a simple, inexpensive project that members and other volunteers can do on a work day. Such work days are also good learning experiences, reducing anxiety about doing such work, thus increasing the probability that those involved will "go and do likewise" in other needed locations, such as their own homes. MassIPL can help organize this kind of event.

Once at the location, delivery should match space type and use. For example, in-floor forced air vents in large/high worship spaces are very inefficient, blowing warm or cooled air to the ceiling, rather than distributing at the level of people. (7± foot maximum) Similarly exposed steam radiators in classrooms (especially nursery and pre-school) is a harm risk to occupants. There are now ***"high-efficiency" radiators*** that can be wall-mounted, including in classrooms. Even better for classrooms (especially where kids crawl on the floor) and in large and/or high spaces (such as meeting halls and sanctuaries) is ***in-floor radiant***. This can be installed over existing flooring, or if accessible from below, beneath the current flooring. Use of in-floor radiant is beneficial in classrooms and worship spaces because heat will be uniform throughout the space, delivered where the kids or people are. The heat "pools" slowly, staying at the base of the space rather than going upwards to the ceiling. This system can be zoned within large spaces so that for small gatherings, the participants can be clustered at the heated area, which is beneficial in both energy efficiency and community formation.

Evaluation

Due to the size of the building and the complexity of the system, there is a large network of distribution pipes, especially visible in the boiler room (See photo H-10). They are well-insulated, though it was noted on the site visit that at least some of the insulation contains asbestos; any work done on the distribution system must be done with proper procedures for containment and removal of the asbestos. The main distribution pipes for the 4 zones each have a controller (see Photos H-11 through H-14) that signals the boiler to come on when the thermostat in the zone calls for heat (such as Photo H-15, the thermostat for the RE Wing).

Different delivery equipment serves different areas: a convection system from radiators through grates in the floor in the Sanctuary (see Photo H-16), radiators (see photos H-17 and H-18), and forced air in Winsor (see Photo H-19, with associated blower H-20) and Meyer Chapel (the blower shown in Photo H-21 is located in the closet off Winsor with its associated controller shown in Photo H-22). Meyer Chapel is also served by an Energy Recovery Ventilator (ERV), a device that brings in fresh outside air, exhausts stale inside air and through a heat exchanger, moves the heat from the exhaust to the incoming air (see Photos H-23 and H-24). This maintains a high quality for the indoor air and is most needed during times of maximum occupancy; the unit also provides dehumidification. A similar unit serves Metcalf Hall (see Photo H-25)

The air conditioning unit for the Offices delivers the conditioned air though a typical duct system to vents in several locations. Discussion of options for replacing this with a heat pump is included in the A/C question above.

The pipes from the hot water heater are not insulated (see Photo H-26). This is a simple project requiring only insulating sleeves that are inexpensive and available at the hardware store or home center.

Do you have water-efficient faucets and toilets? Yes

Water is another scarce resource that is often taken for granted but should be part of your environmental stewardship. There is also an energy connection: it takes considerable amounts of energy to pump the water, treat it, send it to you, then treat the wastewater. Reducing water use also reduces this energy. Many faucet aerators are 2.2 gallons per minute (gpm) when 0.5 gpm is sufficient for restrooms, 1.5 gpm for kitchens; installing faucet aerators is easy and inexpensive.

Toilets use 1.6 gallons per flush (gpf), or more (5+ gpf) if the toilet is old (before 1992). Given the higher gpf needed to flush defecation, and that the ratio of urination to defection of about 6:1, it means that for 6 out of 7 flushes more water is used than needed. Dual-flush converters are less than $20, and are easy to install. Each involves an environmental stewardship practice readily followed at work, homes, schools, day care centers and so on.

These are easy projects that members and volunteers can do on a work day. When replacing fixtures, look for the *Water Sense* logo, the water equivalent of the *Energy Star* label. (See http://www.epa.gov/WaterSense/about_us/watersense_label.html for more information.) Also see MassIPL's *Everyday Environmental Stewardship* brief on *Sinks and Toilets*.

Evaluation

All toilets are relatively new 1.8 gpf and sinks appeared to have aerators. At least one toilet is Water Sense labeled (See photo #Y.)

Special Notes on Heating

Given that heating equipment (generation, distribution, controls) can be costly (though probably not as costly as the aggregate cost of the cars owned by members to drive to services – yes, all costs are relative!) a **studied process** to determine the equipment to be used is sensible. Key factors include operating cost, life expectancy of equipment, ease of operation, care and maintenance, and improved comfort in spaces when in use.

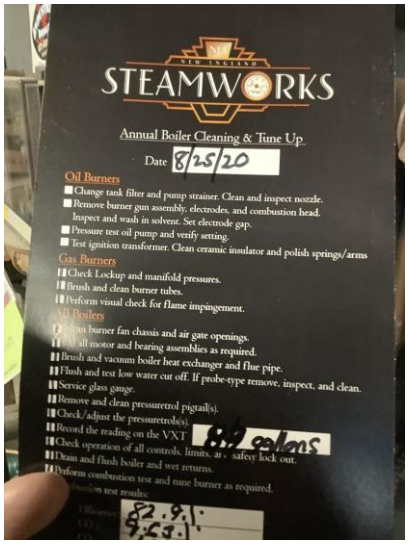
A very basic action if the HOW has boilers for heating is to **switch from steam to hydronic**, if steam is the current system. Steam has an inherent inefficiency, as it heats water to 212° regardless of outside temperature. Thus the functional efficiency of steam is lower, especially in "shoulder" seasons of spring and fall before and after the truly cold times of deep winter. Switching from steam to hydronic (especially with new distribution and maximizing zones will decrease fuel use, carbon emissions, and cost by as much as 60±%. In the change from steam to hydronic, remove the steam radiators. Do not use steam radiators for hydronic heating, for age reasons but especially because they are very inefficient. Large steam pipes might be able to be used as "chases" for the new *Pex* (flexible pipe) pipe distribution. "High-efficiency" radiators maximize heat delivery, with high surface to water volume ratio. They are an integrated part of the overall heat system design. Each radiation solution is sized to match room heat load requirements. This will significantly improve occupant comfort, and reduce fuel use.

An important action is to hire a **mechanical engineer** (ME) to plan and design the new system, especially if it includes new generation, distribution and controls. The ME will provide system specifications that will be used to obtain competitive bids from contractors. Note that if conversion from steam to hydronic cannot occur all at once, begin with the most used spaces. Typically this means that the worship space is the last to be changed.

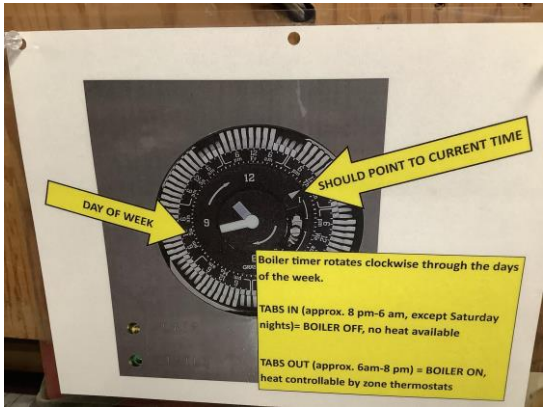
A practical action is to have a good equipment ***maintenance contract*** with a prepared and knowledgeable service company. Just as a well-tuned car gets more miles per gallon, well-maintained heating and cooling equipment uses less energy and lasts longer. This is especially true for steam systems where steam traps need annual inspection and periodic maintenance and replacement, while the entire system needs a "blowdown" at regular intervals to maintain efficiency, prevent corrosion and extend equipment life. Follow your HVAC contractor's recommendation for your system. In recent years, WUS has caught up on deferred maintenance of the system and it appears to be in good working order. Maintain an annual service schedule with your HVAC contractor. DO NOT skip this required maintenance even in years where the budget is tight: it will cost you more in fuel costs and other service calls down the road.

HVAC Photos – Generation and Distribution

H1 — WUS has a large steam boiler that serves the entire building. Even if only 1 zone calls for heat the boiler must fire up so in a building with variable use patterns by zone, this is inefficient.



H2 — Steam boilers require regular maintenance and this label shows the most recent service was on 8/25/20. 82.9% efficiency is acceptable for equipment of this type and age but newer boilers can reach 97%.



H3 — The boiler is on a timer that shuts it off during periods when the building is not in use. Excellent instructions and explanation so future property persons know why this is here.

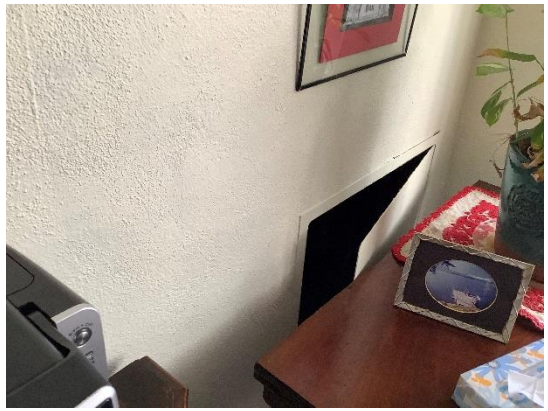
H4 -- Ruud 67-gallon hot water heater serves the entire building but located far from most points of use.

.H-5 -- Pilot light for the hot water heater burns gas 24x7x365.

H-6 – The air conditioning compressor services the offices and shows signs of age.

HVAC Photos: Distribution and Controls

H-7 – The label for the office air conditioner shows the unit was manufactured in 2003, thus is nearing the end of its useful life.



H-8 This access panel in the Senior Minister's office allows access to the air handler and ductwork for the A/C.

H-9 – Heat pumps offer different types of delivery equipment, such as this floor-mounted unit can be installed to be less obtrusive than the typical "mini-split" wall-hung units.

H-10 — Main steam pipe in boiler room with good insulation.

H-11 — Controller for the RE Wing, located in the Metcalf Kitchen.

H-12 – Sanctuary controller, located in the Boiler Room.

HVAC PHOTOS -- Delivery

There are a number of different delivery systems: convection, radiators, and forced air.

H-13 -- Pipes for Parish House (serves RE Wing, Metcalf and some uncontrolled areas) and Cloister (Offices) with controller for the Office zone.

H-16 – The Sanctuary is heated by radiators under the space with heat rising through grates like these in several different areas.

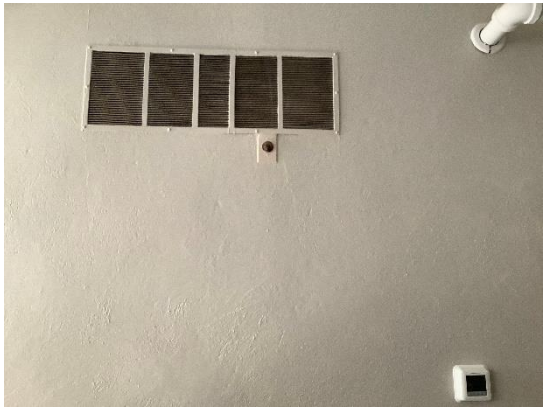
H-14 – Controller for Metcalf Hall, located in ground floor hallway.

H-17 – Steam radiators, like this one in the Main Street entry, are the most common heat delivery system.

H-15– RE Wing Thermostat. Time was set correctly at this and most thermostats, showing that good attention is being paid to ensure heating comes on at correct times.

H-18 – This radiator in Winsor is currently uncontrolled, branching off the line that heats the Sanctuary.

HVAC PHOTOS -- Delivery (continued)



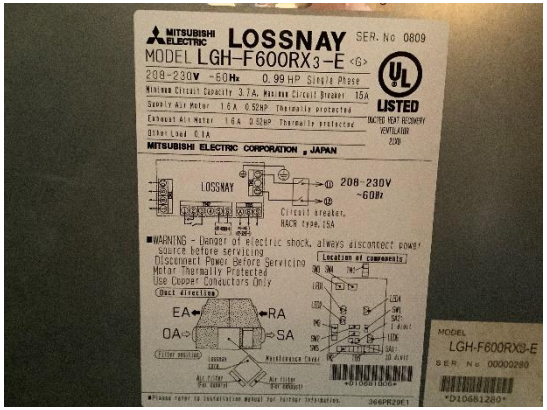
H-19 – This vent provides forced hot air to Winsor and should be used as the primary heat source. Thermostat at bottom right controls the blower.

H-20– This blower unit in the closet off of Winsor delivers heat through the vent shown in photo H-15.

H-21 – The Meyer Chapel blower unit is also located in the closet off Winsor.

H-22 – The controller (orange) for the Chapel blower and economizer

. H-23 – An energy recovers ventilator (ERV) serves the Meyer Chapel, located in the Mourning Room, providing dehumidification and fresh air during times of high activity. It brings in outside air while transferring heat from the exhaust air.



H-24 – This label for the ERV serving the Chapel provides model number and specifications.

HVAC PHOTOS (continued)

H-25 – The new duct work in Metcalf Hall (above the windows) connects to an ERV for dehumidification and fresh air in this space.

H-26 – The hot water pipes from the Ruud tank hot water heater are uninsulated, thus lose a lot of their heat on the long path to the Metcalf Kitchen and bathrooms. Insulating these pipes is a simple project with this insulation readily available at the hardware store or home center.