BERDO Compliance Case Study
First Unitarian Universalist Society in Newton

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The proposed Building Emission Reductions and Disclosure Ordinance (BERDO) is expected to present a challenge for building owners and managers, including houses of worship. In order to better understand how these challenges can be met, this case study examines how First Unitarian Universalist Society in Newton succeeded in reducing its greenhouse gas emissions to a level that puts it in compliance with BERDO until 2045.

The Building

FUUSN was designed as a Unitarian church by noted architect Ralph Adams Cram and completed in 1906. It is listed on the National Register of Historic Places and has an historic preservation agreement administered by the Massachusetts Historical Commission. The building is in English Gothic style and is meant to look as if it had grown organically but was designed as a whole.

The original four wings of the building contain the Sanctuary, a Parish Hall, offices, a kitchen, and activity and meeting areas located around what was a central courtyard. In the 1950s, the courtyard was filled in to create classrooms, restrooms, a first-floor kitchen, and basement space which currently serves as classrooms. With the courtyard addition the

building has a total of **30,241 square feet** of conditioned space. The Society numbers approximately **400 congregants**.

The first-floor courtyard classrooms are currently rented to a preschool which also uses the adjacent kitchen, restrooms, and Parish Hall. The historic parlors on the Washington Street side are used for meeting space and the second-floor historic banquet hall is now called the HeadStart Room as a legacy of the first Newton HeadStart program once held in that space. The historic kitchen is also on the second floor, formerly accessed by a dumb waiter from the basement storage room which for some years served as Newton's food pantry. **Each of these spaces has its own specific schedule for occupancy. Some are fixed from week to week while others also host special events.**

The **original heating plant** was two coal-fired steam boilers, fed manually daily, heating the original building as a single zone. Probably around World War II the steam boilers were converted to oil firing and the steam heating system was divided into four zones with thermostat controls. The "courtyard" building was originally heated by two gas-fired, warm air furnaces serving three zones. In the 1970s insulation was added to the Parish Hall ceiling to reduce heat loss. This affected the acoustics in the hall such that the Music Director vetoed doing the same in the Sanctuary. Window air conditioners have never been used at FUUSN, due to the unique and protected nature of the windows.

The Process

In the late 1990s we embarked on a program of upgrading the energy systems in the building. Our goal was to reduce the operating costs of heating and cooling, to provide year-round comfort for the occupants (such as improved heating in some offices and overall air conditioning to enable greater summer use and rentability), and to reduce environmental impacts.

The general strategy has been to:

- Introduce changes in stages. Take advantage of necessary building improvements, such as new floors or replacement of malfunctioning equipment in order to introduce energy-saving features.
- Create function-based zones with remotely accessible controls for comfortable heating and cooling during occupied periods and deep setbacks during unoccupied periods, typically 55°F for heating and 80°F for cooling. **We believe this is the improvement that most clearly accounts for our current low level of greenhouse gas emissions.**
- Deploy the most efficient technologies available. For example, replace failing air-conditioning condensers with heat pumps.

- Consistently track energy use in each zone and the building as a whole. FUUSN has been using EPA's Portfolio Manager for several years now, with use and cost data from 2013 on.
- Rely on the expertise of members of the congregation. Since the late 1990s, Bob Persons, an expert in energy technologies (and associate member of Newton Citizens Commission on Energy, and Newton Volunteer Energy Coach), has led a group of church volunteers who designed and helped with implementing the upgrades.

One of the first actions in the late 1990s was to convert the steam boilers from oil to gas firing so the two oil tanks could be removed from the former coal bin to make room for new, smaller, modular, gas-fired hot water boilers that could be staged as needed per weather conditions.

In 2001, the most problematic branch of the steam system was replaced with two gas-fired hot water boilers for the office wing radiators and radiant heat under a much-needed new floor in the Parish Hall. These boilers are 83% efficient and able to use the original flue embedded in the building's tower; condensing boilers could not be used because the required venting would conflict with the building's landmark status. Mini-split air conditioning was also added to four offices and two activity spaces, and ducted split system air conditioning added to the Parish Hall. This allowed separate control of heating and cooling in eight zones. The first attempt at automating heating and cooling scheduling consisted of an early-model PC with temperature sensing and relay boards and a Visual Basic program written by a volunteer.

The remaining steam system branches were replaced in 2006-2007 when the Sanctuary space was renovated. Four more 83% efficient gas-fired hot water boilers were added, and the steam boilers demolished to open up space for a new classroom. Eleven "hydro-air" units were added to heat and cool the three courtyard zones and the remaining portions of the original building. Each of these is connected to the new boilers for heating and to an outdoor condenser for cooling. At this point the home-made control system was replaced with 19 commercial internet-enabled thermostats. These Lightstat eStat thermostats were originally designed for retail store chains and so have a user interface that is a bit inconvenient for scheduling special events. But they are easy for any HVAC contractor to install and much less expensive than packaged building management systems from Honeywell, Johnson Controls, etc.

As a result of all these changes, FUUSN has a 19-zone system. Eleven zones are served by hydro-air units. One of these, the Parish Hall, also has cast iron radiators along the exterior wall to supplement the radiant floor and heat pump coils installed to replace AC coils that

failed. Six zones have mini-split heat pumps mainly for cooling with cast iron radiators for heating backup. A corridor zone has only radiator and one remote zone has only a heat pump. Altogether FUUSN uses 6 boilers, 11 hydro-air units with 10 AC condensers, 6 air-source heat pumps, and numerous radiators.

Currently, we are studying conversion to ground source heat pumps and phasing out the use of gas altogether.

The Outcomes

The graphs below show that the Energy Use Intensity (EUI) based on electricity and gas use is 2.9 $kgCO_2e/ft^2$. 65% of that is from on-site fossil fuel use (2.0) and 35% is from electricity (0.9). If electricity is excluded, as per Newton's proposed BERDO, at 2.0 $kgCO_2e/ft^2$ the building will be in full compliance until 2045 while doing nothing.

The graphs also imply that most of the declines in energy use took place before 2013. We attribute the reduction primarily to **three factors:** staged transition from steam to hot water heat, partitioning of the HVAC system into 19 zones, and deep temperature setbacks during unoccupied periods.

The Financials

Detailed information about the costs of FUUSN's efficiency improvements is not available because they were subcomponents of major renovation projects that were made long ago. In any case it would be irrelevant now due to inflation and the changing market. However, three general points are relevant:

- FUUSN did not receive any state or federal incentives for this work.
- The costs were covered by the annual budgets of the church and by periodic capital campaigns, which have been part of the fiscal management of the church building since its beginnings.
- Free expertise and commitment from members of the congregation were essential for the success of the retrofit projects.

Lessons for houses of worship under BERDO

The lessons from this case study for other houses of worship are:

- In buildings with a variety of space types and intermittent uses, create multiple heating/cooling zones with remotely controllable operating schedules and deep setbacks. BERDO compliance does not have to begin with costly replacement of all gas-fired heating units with air-source heat pumps.

- Put in place a point of responsibility (and appropriate training) for monitoring the functioning of the system and for tracking energy use.
- Reducing carbon emissions from an old house of worship does not have to be an unbearable financial burden if done deliberately, with a good plan, and in stages.

Newton BERDO has two central objectives: to comply with the Massachusetts legal climate obligations by reducing greenhouse gas emissions from all large buildings in Newton; to make long term multiyear energy plans by building owners a standard way of doing business. Compliance with BERDO *cannot be* achieved without such planning. The FUUSN case study is a perfect illustration. It entailed a long-term vision, three decades of gradual well-planned actions, discipline, focus, a strong support from the building occupants, and collective learning.

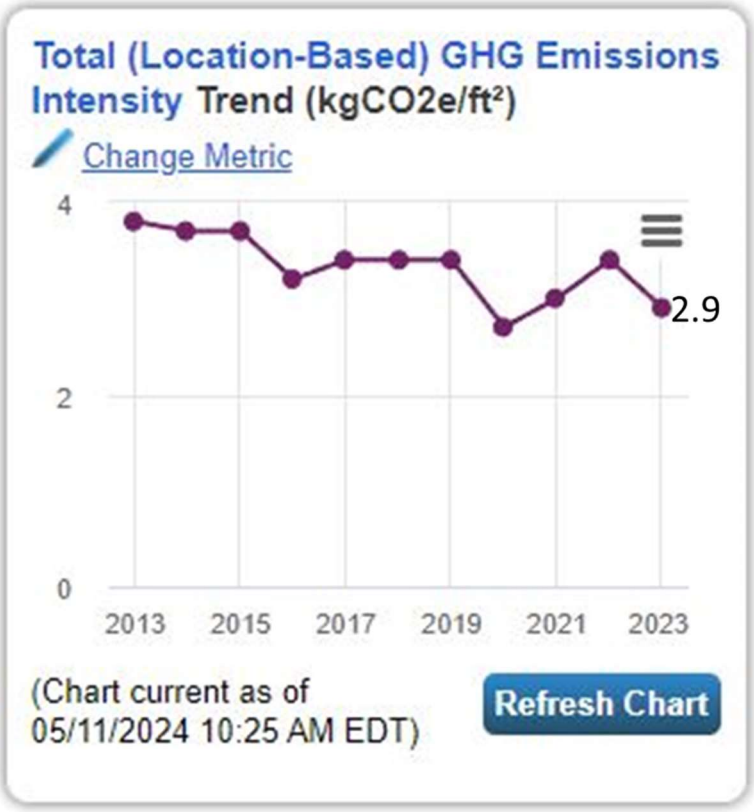

Figure 2 – Emission intensity **2.9** based on both gas and electricity uses

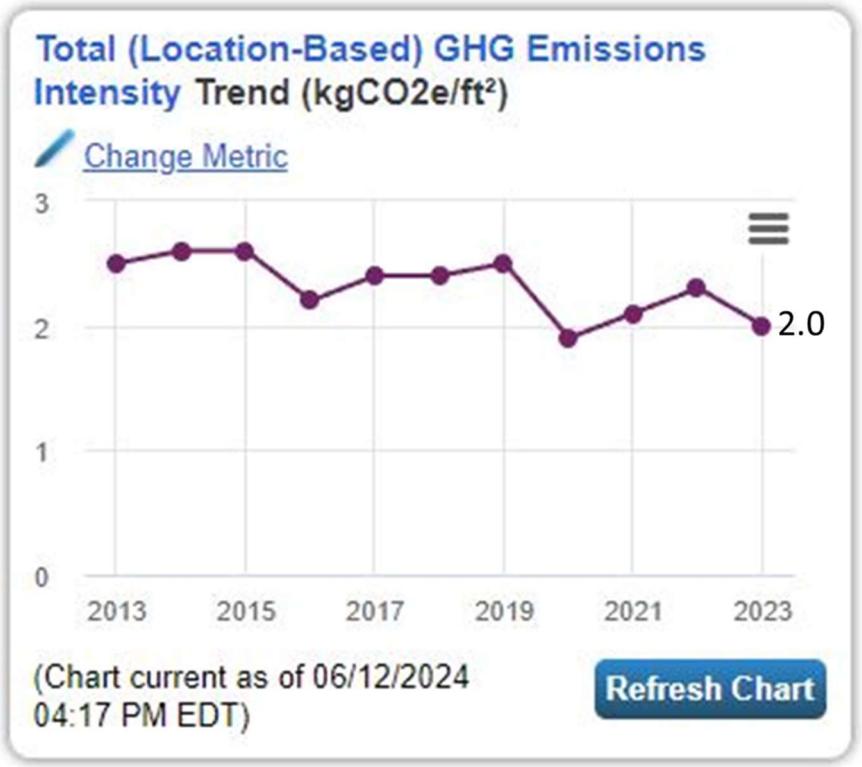

Figure 3. Emission intensity **2.0** based on gas use only

Newton Proposed Rate of Emissions Reduction

Table 1: CO_2e Emissions Standards by Building Use

Building Use	Emission standards ($kgCO_2e$/sq. ft.)				
	Period 1 2027-2033	Period 2 2034-2039	Period 3 2040-2044	Period 4 2045-2049	Period 5 2050-
Assembly	6.1	3.7	2.3	1.1	0
Other building categories omitted for clarity.					

Table 1. Performance targets for houses of worship required by BERDO
From City of Newton Proposed Berdo, Version: WF and PEG 5-16-24

View-only link to June 25, 2024 presentation on "Greening Houses of Worship" sponsored by Green Newton and Massachusetts Interfaith Power & Light:

https://docs.google.com/presentation/d/15_ddNWE5AHWtX8A85zuvwiZfJPfSDNbS/edit?usp=sharing&ouid=103502109132783351555&rtpof=true&sd=true

APPENDIX
Follow-Up Questions and Responses

What firing rate or tons heating are those boilers and what's the operating temperature you're running at, and that your radiators are working at?

> The two boilers that enabled our first move away from steam heating are each rated 166,000 Btu/hr. The four boilers installed to complete the transition from steam to hot water heating are each rated 233,000 Btu/hr. So, the total gas input is 1,264,000 Btu/hr. The two sets of boilers operate as two separate systems, but both use an outdoor temperature reset strategy, supplying 180°F water when it's 0°F outside and 140°F at about 60°F, above which they are in warm weather shutdown mode. The point of the question is that when we convert the system to ground-source heat pumps the highest available supply water temperature at 0°F outdoors might be less than 180°F, and we may need larger hot water radiators. However, a better alternative might be to convert the radiator-heated zones to warm air heating, which can function at much lower supply temperatures.

Is building heat provided entirely or mostly from the six boilers?

> While we have started installing air source heat pumps, most of the building's heat still comes from the gas-fired boilers. Part of the reason for this is that the heat pumps installed so far are not easily integrated with the existing remotely-accessible zone controls.

What is your natural gas energy use index?

> For 2023, the site EUI for gas plus electricity was 50.7 kBtu/ft^2 per Portfolio Manager. Counting only the gas use, it was 37.6 kBtu/ft^2.

Can you make any guess as to what your occupancy rate is?

> See the table below for calculation of the occupancy rate. While the rate seems extremely low, there are several obvious reasons including recovery from Covid-19 membership losses and that many houses of worship have large spaces that are used for only a few hours per week.

FUUSN OCCUPANCY RATE ESTIMATE

Winter 2023-24

Zone	Approximate Area, SF [3]	Occupied Hours including pre-conditioning & post-purge [1]								
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	SF-Hours
Administrator	155	11	9	11	9	11	0	7	58	8,990
Alliance Room	770	0	0	8	5	0	7	8	28	21,560
Classroom B-7 [2]	620	0	0	0	0	0	0	6	6	3,720
Ctyd 1 North	2,125	18	18	18	18	18	18	14	122	259,250
Ctyd 1 South	2,125	18	18	18	18	18	18	14	122	259,250
Ctyd Bsmt	2,821	0	0	0	0	0	0	6	6	16,926
Headstart Room	1,192	0	0	5	8	0	0	7.5	20.5	24,436
Minister	268	11	0	11	11	0	0	6.5	39.5	10,586
Narthex	784	0	0	0	0	0	0	10	10	7,840
Membership	121	10	9	9	0	0	0	6	34	4,114
Religious Ed	121	11	0	11	11	11	0	6.5	50.5	6,111
Office Corridor	335	15	15	15	15	15	15	7	97	32,495
Parish Hall	2,090	0	0	6	0	0	0	10	16	33,440
Parlor Area	1,074	15	16	15.5	15	16	16	15	108.5	116,529
Sanctuary	5,453	0	0	0	0	0	0	10	10	54,530
Stage	531	0	0	0	0	0	0	9	9	4,779
Tower Room	289	0	0	5	8	0	0	7.5	20.5	5,925
Upper Kitchen	498	0	0	5	8	0	0	7.5	20.5	10,209
Youth Room	531	0	0	0	0	0	0	10	10	5,310
TOTALS	21,903									885,999
									SF-hours / Area / 8,760 =	**0.46%**

Notes

[1] This estimate counts only regular weekly schedules and excludes special events.

[2] Includes boiler room.

[3] Excludes former (unheated) food pantry, 2nd floor vestibule & rest rooms, Sanctuary balcony.