ASHRAE Level 1 Energy Audit Report

for

St. James of Jerusalem Episcopal Church

220 West Penn Street, Long Beach, NY 11561

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ENVIRONMENTAL
GREEN BUSINESS SOLUTIONS

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Summary

St. James of Jerusalem Episcopal Church, Long Beach, NY (St. James) seeks to reduce its greenhouse gas emissions and improve its resilience to major storms. St. James has engaged EMS Environmental, Bethlehem, PA (EMS) to conduct an ASHRAE Level 1 energy audit to address these objectives. EMS Environmental has analyzed energy use, operating information, and historical data and conducted an on-site inventory and review of operations. From this information, EMS analyzed the current situation and prepared possible paths for improvement for the Church and Rectory. This report summarizes that assessment and recommended improvements.

Nearly 90% of the energy consumed by the church and rectory comes from natural gas, a major contributor of carbon dioxide to the atmosphere. Electricity currently purchased is not much better than the natural gas, deriving 77% of its generation from fossil fuels. There are multiple approaches to reduce these emissions to help St. James become a better steward of the planet. These approaches include: changing the source of the energy, switching the use from one source of energy to another (fuel switching); making operational changes to reduce energy use; and investing in technology to reduce energy use. EMS proposes all of these approaches with consideration and quantification of the costs and benefits for the recommended changes relative to both environmental and resiliency improvement.

St. James Episcopal church and rectory were built in the mid-1930s and have not been upgraded with insulation or air sealing to improve energy efficiency. The gas boiler heating source remains approximately the same as the original in operation and efficiency. The one outstanding feature from an energy perspective are the mini-split heat pump air conditioners used for the Church (Sanctuary, Sacristy, Office and Undercroft). Otherwise, caretakers have been diligent about updating to LED lights. In addition, a few of the appliances are ENERGY STAR rated. Operationally, due to its schedule and modest pyrotechnics (lights, audio-visual amenities), St. James Episcopal uses very little electricity, less than that of the single family average home. However, what it uses is inefficiently used. Should active-ties and occupancy levels increase, energy use will dramatically increase as was the case back in 2016.

The changes, or Environmental Conservation Measures (ECM) recommended are both large and small. Some can be enacted immediately and some will take multiple years to plan and implement. The recommended ECMs are listed in the back of the report. A summary of the ECMs are listed below:

- Switch PSEG electric supply to Green Source option, which is nominally 100% renewable
- Heat church facility with existing mini-split heat pumps rather than gas boilers
- increase capacity of basement mini-split and replace rectory air conditioner with a heat pump to further the progress of fuel switching
- Replace existing gas water heaters with electric heat pump water heaters for fuel switching and efficiency
- Air seal and insulate uninsulated portions (88%) of the church and rectory walls and roof to improve efficiency and comfort
- Upgrade faucets, lights and appliances to enable fuel switching and reduce energy use

The next steps for implementing the energy saving projects are outlined in the latter part of the report, including information on utility rebates.

ASHRAE Level 1 Energy Audit

The ASHRAE Level 1 Energy Audit provides an excellent format for investigating, analyzing, synthesizing and organizing a Greenhouse Gas emissions evaluation of St. James of Jerusalem Church and Rectory. This assessment deviates from the standard in that it is driven not by energy cost, but carbon dioxide-equivalent emissions. These two objectives are closely aligned, but not identical. In this case, the source of the energy consumed is more important than the cost of that energy. The focus of the energy audit is ultimately never about the cost of that energy, but the amount of energy that is consumed. Reducing energy consumption reduces energy cost, but more importantly, it also reduces the environmental impact of that energy use, which for nearly all forms of energy generation has at least some environmental cost.

The ASHRAE Level 1 Energy Audit includes an inventory and assessment of current energy supply and energy use. From this current assessment, improvements, or Energy Conservation Measures, can be identified and compared for their cost versus benefit. The recommended improvements can then be evaluated and integrated into an energy reduction plan that meets the objectives and constraints of St. James.

Scope

The scope of the Level 1 Energy Audit includes St. James of Jerusalem church, rectory, and shared grounds. It does not include the impact visitors or staff bring to the building, such as transportation, personal use and/or consumable products, food, etc. It does not include the embodied energy in equipment, furniture, finishing, appliances, etc.

Objectives

1. Evaluate the current greenhouse gas emissions footprint of the church and rectory.
2. Identify opportunities for improvement and assess relative value of each
3. Recommend an improvement plan which considers both reduction in carbon emissions and resiliency to weather events, particularly flooding.

Overall Assessment

St. James of Jerusalem Episcopal is located in the humid subtropical climate zone. Temperatures are generally above freezing in the winter. Summer conditions typically last from late May to early mid-October. Also, the heat island effect of New York City contributes to higher than natural nighttime temperatures in western Long Island. The result is relatively low demand for winter heating and moderate to significant temperature and humidity issues in the summer.

Located just above sea level, 1-½ blocks from the ocean with a 5-6 feet high berm offering not much protection from the ocean, flooding is of significant concern. Hurricane Sandy (Nov 2012) resulted in the need to replace the boilers and other items located in the basement. Also in response to Sandy, St. James blocked off and filled-in the ramp to the rectory garage to remove a flood path into the rectory basement.

St. James resides on approximately ½ acre at 220 West Penn Street, Long Beach, NY 11561. The property has two temperature conditioned buildings, the church and structurally connected rectory.

The church was built in 1935 and the rectory added in 1937. The overcroft was finished in approximately 2011. No other structural or building envelope changes have been made.

The church has one main level, where the Sanctuary (30'x65' = 1950 square feet, or sf) and Sacristy are located. Above the Sacristy is an Overcroft (used as an office) located in the attic. Below the Sanctuary and Sacristy is a finished basement or Undercroft, which is used for meetings and events. The undercroft includes stair access from the first floor hall, front entry vestibule, large multi-purpose room, kitchen, boiler room, storage space and two restrooms. Overall, the church has about 4500 sf of conditioned space.

The rectory was originally accessible from the church, but that access door was walled off in the 1970s. The rectory is two floors with a full basement (unfinished). The first floor consists of a front hall, living room, hall and stairs to the second floor, side entrance and hall with access to stairs to the basement, dining room and kitchen. There is a front raised porch, where the front door is located. The second floor consists of hallway, one full bath and three bedrooms. There is a closet in the 2nd floor hallway with access to the attic. Overall, the rectory has about 1300 sf of conditioned space (attic and basement not conditioned).

The church is currently open just for a single Sunday service and any special events. The undercroft is used for regular meetings every day except Sunday, but only for a couple of hours at a time. Total building occupation is currently only about 30 hours per week (see Schedule in Appendix) or about 18%. The rectory is currently occupied as a home for the priest. The hours of use are estimated to be about 13 hours per day or about 54% occupied. Sunday service was offered only virtually during Covid. Physical services and undercroft meetings ceased in March 2020 and resumed in June 2021.

Since the church and rectory were originally built, the combined buildings have gone through relatively minor changes, such that the result is a very inefficient building from an energy efficiency perspective. There is very little insulation and minimal provisions for air sealing. The boilers are on the low end of typical efficiencies. The windows in the rectory have been upgraded and pretty efficient. The one outstanding feature from an energy perspective are the mini-split heat pumps used for the Church (Sanctuary, Sacristy, Office and Undercroft). Otherwise, caretakers have been diligent about updating to LED lights. In addition, a few of the appliances are ENERGY STAR rated. Operationally, due to its schedule and modest pyrotechnics (lights, audio-visual amenities), St. James uses very little electricity, less than that of the single family average home (12,000 kWh).

Mechanical equipment has been replaced as needed. In 2013, very efficient air conditioning was added to the church in all spaces (Sanctuary, sacristy, undercroft, overcroft). Gas boilers and domestic Water Heaters (DWH) were not improved, even for available, more efficient options. There are significant opportunities for improvement.

The appliances in the church and rectory are relatively efficient. Both dishwashers are ENERGY STAR certified. There are opportunities for improvement.

St. James has upgraded nearly all of its lighting to Compact Fluorescent Lamps (CFL) or Light Emitting Diode (LED) lamps, including state of the art LED panel lights in the undercroft. There are opportunities for improvement in a few locations.

Overall, the facilities use very little energy, but this is due to their modest size, modest operations and marginal use. Should the use levels of the facilities increase, energy use will increase significantly, as was demonstrated in 2016, when the combined electric use was double what it was in 2020.

Due to the Covid interruption and the rectory being unoccupied from February 2017 to July 2019, determining normal energy use over the last 5-10 years would have little validity. Further, it may be a couple of years before the event of a “normal” use year. Unfortunately, a baseline for comparing greenhouse gas emissions will need to be established over the next 3-5 years. In the meantime, 2016 has been selected as the baseline because it was the last year the rectory was fully occupied and Covid was not affecting facility use.

This report will first address energy usage and procurement and then focus on how that energy is consumed. With this understanding, the report investigates what can be done to further reduce energy use.

Current Greenhouse Gas Emissions

The electricity St. James purchases comes from the New York State electric grid, which is managed by the New York Independent System Operator (NY ISO), an independent entity which manages the New York wholesale electricity market. NY ISO is regulated by the Federal Energy Regulatory Commission (FERC). Because NY ISO manages the market, it tracks the source of electricity sold and who it is sold to. PSEG Long Island is one of the purchasers in this market. The mix of electric sources varies dynamically by the minute so the greenhouse gas emissions per unit of electricity use, the kilowatt-hour, or kWh, varies by the minute. However, NY ISO maintains aggregate data on the energy sources for its electric power in an average kWh in a given year. For 2020, the aggregate for downstate New York **was 77% Fossil Fuels, 21% Zero-emissions (Nuclear, Hydro); 2% Hydro Pumped Storage; and 1% Other Renewables, including Solar.** Power from upstate New York is cleaner and could find its way to PSEG, but on the whole electric used is produced locally. The downstate sources are projected to become much cleaner by 2030 and NY ISO is actively working on transmission and generation programs that will yield a cleaner electric grid. One significant potential contributor is off-shore wind proposed off Long Island, which would shift clean energy well into the majority. However, the rate of change is out of St. James’ direct control.

Energy Costs

St. James uses electricity and natural gas to heat and cool the church and rectory, heat domestic water, and support domestic and event operations. In 2016, St. James used about 2600 Therms of Natural Gas and about 18,000 kWh of electricity. This has varied significantly over the years, as covered in the next section of this report. At 2016 consumption levels, St. James would be paying about $6,200 per year for energy.

The current cost for that level of electric use is approximately $3,600. Of that, about $185 is in fixed fees. The current cost for that amount of natural gas use is approximately $2,600. Of that about $83 is in fixed fees. For both electric and gas, the cost is driven almost entirely by consumption levels. **By managing consumption, St. James can manage its energy costs along with its greenhouse gas emissions**.

Electricity

Electricity can have two kinds of consumption charges: electric use (kilowatt-hours or kWh) and electric demand (kilowatts or kW). Because it is a small consumer of electricity, St. James does not pay a demand charge. The electric demand is the measure of the maximum amount of electricity used on St. James meters during any 15 minutes of that billing month (off-peak or on-peak). It is like a month-to-month purchase contract for which St. James can control the volume, but it is set at the biggest surge point of the month. Because Demand charges do not apply and Demand levels are not metered, Demand will not be further discussed in this report. Further kWh per hour, or kWh/h provides a blunted approximation of Demand levels; so it can be used as a proxy for evaluating the Demand levels that affect the cleanliness of the electric grid.

St. James is charged a monthly service fee electric service plus a use rate per kWh. The current usage rate is 18.2 cents/kWh in winter, including both supply and distribution. During the summer (June 1 to September 30), the rate increases another 2.3 cents/kWh to 20.5 cents/kWh. St. James is on a fixed rate tariff; so the cost per kWh does not vary by time of day. If this Time of Use (TOU) rate were available, it is not recommended for St. James' due to St. James current (and probably any future) use pattern.

Electricity costs are broken into generation, or supply, and distribution. Distribution is a regulated service regulated by the New York Department of Public Service, which approves both the rate types allowed and the rates that can be charged (tariffs). New York State energy generation, or supply, is deregulated. Customers can select a supplier registered in the NY ISO market. However, the market is not well developed and there are not many competitors registered in the market; so most consumers purchase their supply through their distributor (supplier of last resort).

St. James purchases its electricity from PSEG (Public Service Enterprise Group), an electric service provider with a 12 year agreement (2014-2026) with Long Island Power Authority, which owns the electric distribution system on Long Island. PSEG administers the distribution and bills St. James at regulated rates as approved by the New York Department of Public Service. PSEG also bills St. James for the generation, or supply, of the electricity that is delivered. It provides the electricity at the NY ISO market cost plus administration fee.

The deregulated electric supply market offers an opportunity for some cost savings, but more important to St. James, it offers an opportunity for significantly reduced greenhouse gas emissions by selecting a supplier which supplies renewable energy versus fossil fuel generated electricity. PSEG offers a Green Choice on its website: https://www.psegliny.com/myaccount/serviceandrates/greenchoice Selecting Green Choice has a premium cost of $10-$20 per month (PSEG's estimate) and limited supplier options, but it addresses the electric use source in a manner that has value.

All electricity is mixed together in the grid. Generators push their electricity into the grid from wherever and by whatever generates the electricity. If a renewable energy supplier generates electricity and sells it into the market, that electricity is going to be used instead of fossil fuel generated electricity, which reduces the overall emissions of the grid. If St. James buys the electricity it uses from a renewable source, it is directly reducing the grid and its emissions in the amount that was purchased. This has the same greenhouse gas emissions impact of having its own solar panels and producing its own electricity. What is important is verifying that the electricity it purchases is truly and totally from renewable sources. There is a wind energy aggregator among the PSEG Green Choice options. There is also one other supplier supplying renewable energy. These choices need to be verified as to their renewable energy claims as part of St. James' due diligence. Some of these companies are brokers or agents selling the actual generation; others may be using the premium funds to invest in renewable energy generation. The latter requires more scrutiny.

Instead of purchasing renewable energy, St. James can generate it on-site with solar photovoltaic panels. The rectory is ideally oriented to place solar panels on the back (south) roof. Approximately, 4800 watts of generation could be placed on 16 panels to provide about 7,000 kWh per year or 1/3 to 2/3 of current electric consumption. With electrification, this consumption will not likely go down; so the on-site production would like likely not address all its electric consumption needs, but it would be a strong contribution and an example for the community. St. James could purchase a solar array and grid interface system, or lease it or host the system owned by others. St. James would be eligible for a tax credit that could be transferred to the solar panel owner in return for electric bill reduction, royalties, solar credits or eventual ownership of the system.

Natural Gas

St. James' gas consumption is based on Therms delivered. The Therm is an aggregate unit of energy use equivalent to 100,000 BTUs of heat energy. The natural gas meter measures in 100 Cubic Feet (CCF) units that is converted on the gas bill to Therms based using a close to 1:1 ratio of how much energy can be converted from that volume of gas, which depends on the natural gas composition. On a rough basis, a CCF is equivalent to a Therm.

Like electricity, natural gas costs are broken into generation, or supply, and distribution. Distribution is a regulated service regulated by the New York Department of Public Service, which approves both the rate types allowed and the rates that can be charged. New York State energy generation, or supply, is deregulated. Customers can select a supplier registered in the local market. However, the market is not well developed and there are not many competitors registered in the markets; so most consumers purchase their supply through their distributor (supplier of last resort).

St. James purchases natural gas from National Grid. National Grid owns the natural gas distribution system on Long Island. St. James also purchases the gas supply from National Grid at market rate plus administration cost. The supply rates vary seasonally and from year to year based on market demand and supply cost (extraction and transportation via pipeline and/or other means to National Grid).

St. James could marginally improve the environmental impact of the Natural Gas it purchases by selecting another supplier. However, natural gas has much different properties than electricity; so the gains would be very small and the effort to track changing conditions very high. The effort would be much better spent on reducing the use of natural gas as a means to reduce greenhouse gas emissions.

Electric and Natural Gas Equivalency

Natural gas heat energy can be compared with electric energy to generate the equivalent heat. At 100% efficiency, the conversion is 29.3 kWh per Therm. At current gas prices, the kWh equivalent would be .034 cents/kWh. At current electric rates, electricity would be $5.56/Therm. This disparity is quite significant, making the conversion from gas to electric use, the more attractive from a greenhouse gas emissions perspective, an economically expensive one. From this perspective, electrification alone is difficult to recommend without additional efficiency improvements.

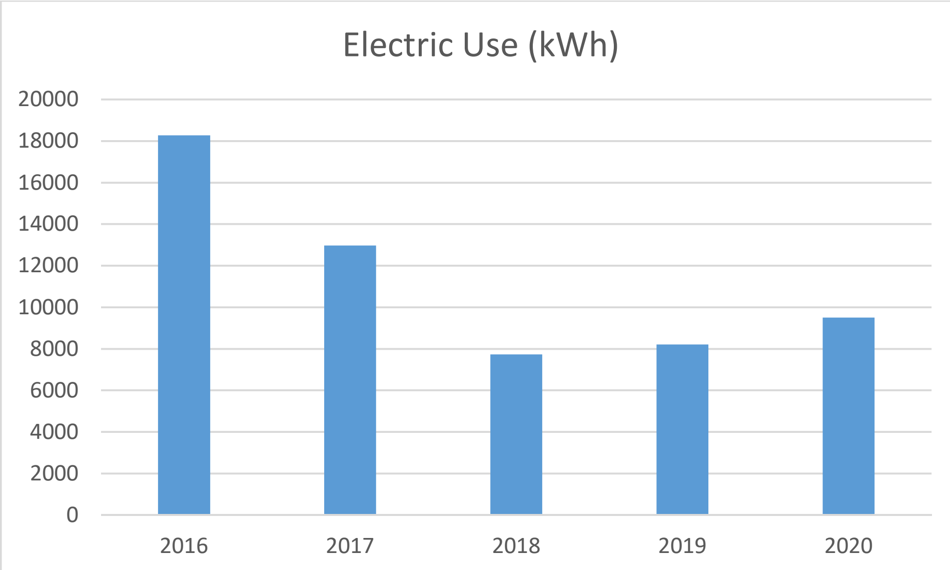
Energy Procurement Recommendations

St. James can reduce its greenhouse gas emissions most cost effectively through purchase of renewable energy through the PSEG Green option. Simply electrifying the natural gas use would be expensive, costing over $14,000 per year, or more than tripling the cost St. James pays for energy. Fortunately, there can be significantly more efficient options to make the energy costs of this conversion much less expensive.

Tracking the kWh on the electric bill and Therms on the gas bill will provide an important metric for evaluating greenhouse gas emissions and cost. Logging these two measures should be included in standard financial record keeping procedures at St. James.

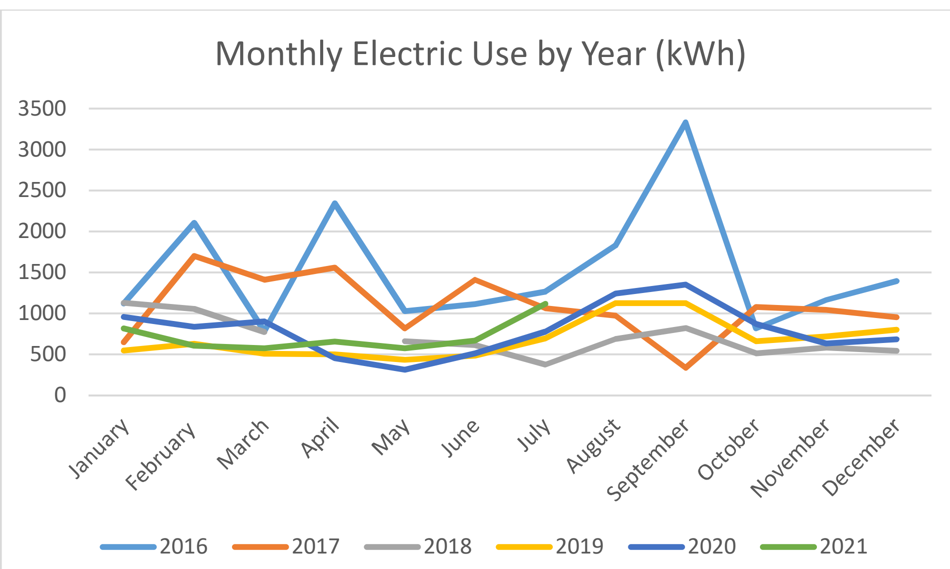
Electric Use

Below is the annual electric use for St. James.



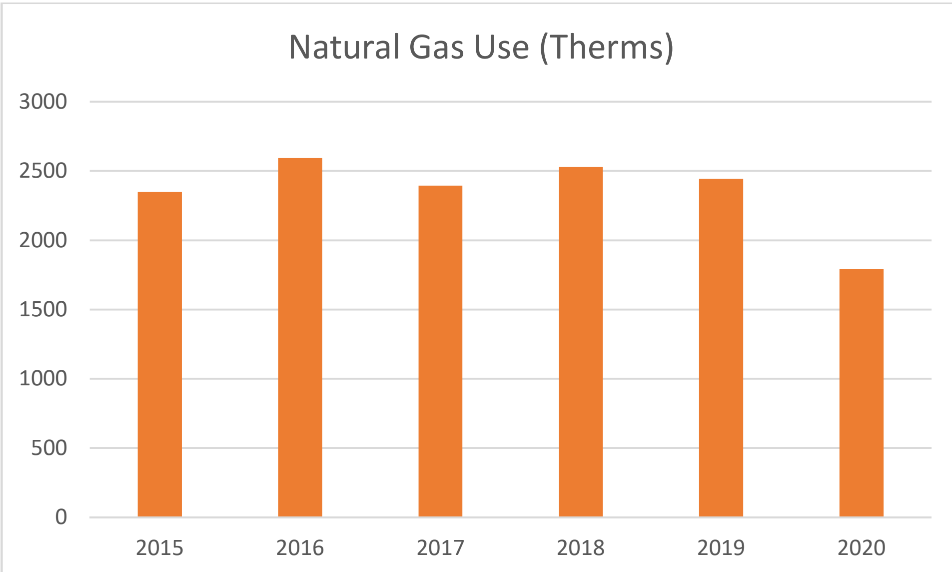
Electric use has varied significantly over the last six years, with 2016 use 2.36 times that of 2018. Most of this difference is attributed to the lapse in occupancy of the rectory from February 2017 through June 2019. Covid cut backs in facility use could explain the continued reduced electric use levels in 2020. With a different occupant than the previous occupants in the rectory and different activity programming, the usage level may not return to 2016 levels.

Electric use varies throughout the year, depending on season (daylight hours vs. night hours), seasonal events (holidays for the church, travel schedules for the rectory), and weather (heating, air conditioning). Another view taken of the data on an annualized basis shows the seasonality of electric use. Below is the Month by Month Year over Year electric use over all accounts for St. James.



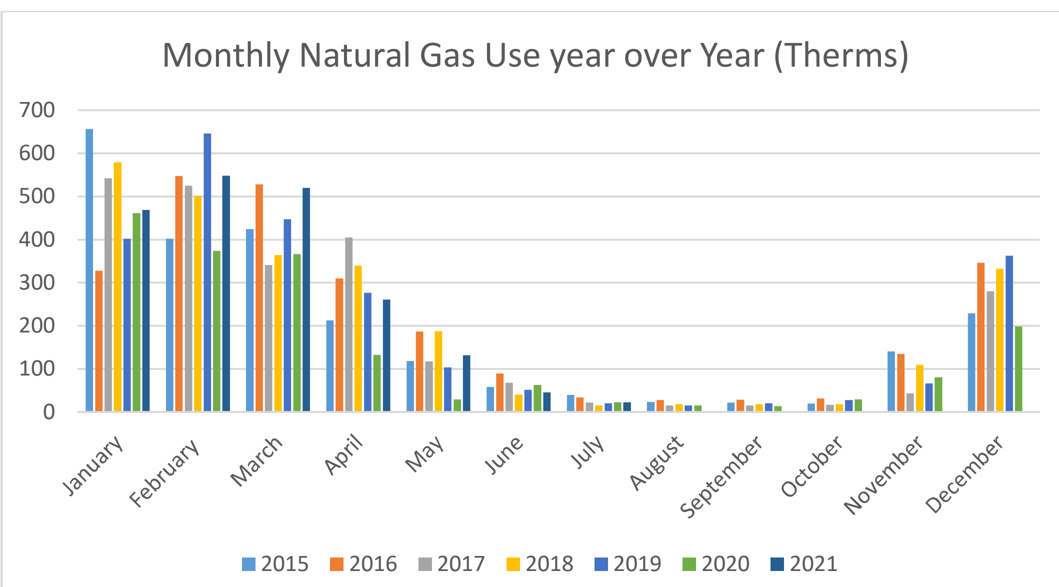
From this chart, 2016 versus 2017 and 2018 from occupied to unoccupied rectory illustrate lack or much less use of air conditioning (which is available both to the rectory and church). Air conditioning is of course also a function of the weather and occupancy levels calling for it. Warmer weather and increased occupancy schedule for the church could refine this understanding to potentially a quantifiable correlation.

Natural Gas Use



Natural gas use has been much more consistent than electric use. Up until 2020, natural gas use averaged 2,462 Therms with a standard deviation of only 99 Therms. In 2020, due to the impact of Covid, use dropped significantly (27%). With the rectory nominally occupied, this drop suggests that the church relative size to the rectory and its closed state enabled lowered temperatures to be maintained. If that condition is the cause, then that suggests that transferring more heating load to the mini-split heat pumps would be a viable means to reducing natural gas greenhouse gas emissions.

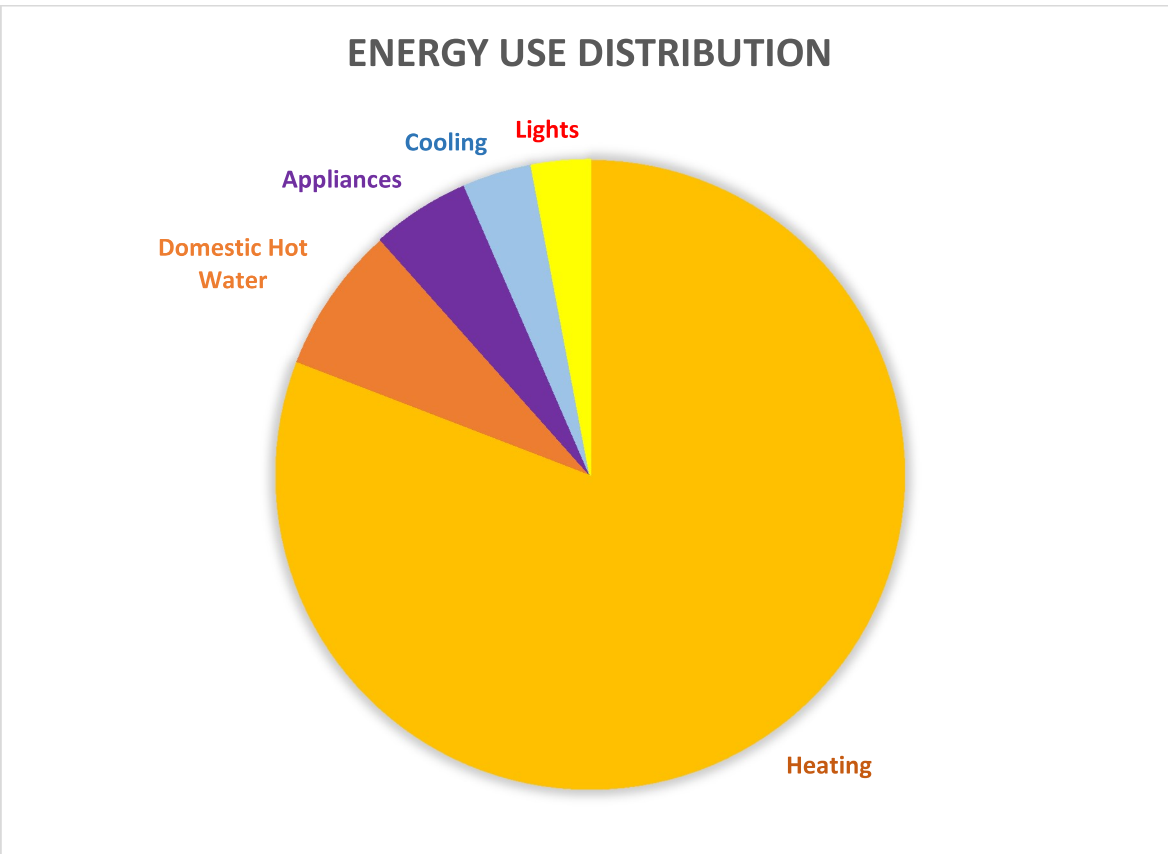
Looking at use seasonally, month by month, year over year, also illustrates the consistent seasonal use of gas at St. James.



Energy Use Contributors

Energy is used by many individual devices throughout the church and rectory. Determining which devices use how much energy and whether that energy use can be reduced requires an assessment or inventory of all the energy consuming devices on the property.

There are multiple tools to discern and quantify individual consumers of energy such as equipment nameplates, industry standards, scheduled operating hours, and proxies for power, such as water consumption. The actual consumption measurement is not part of an ASHRAE Level 1 audit. However, due to the importance in this case for informing critical energy audit questions, it has been included in the audit in order to evaluate the relative contributors of energy use to inform recommendations, and particularly to assist in the consideration of fuel switching to reduce carbon emissions. This process involves what is known as an "energy balance" looking at the nameplate power, an understanding of what average power is relative to nameplate, and operating hours versus the total meter energy consumption. In this case, the balance uses the two separate electric and gas meters as an additional means to "balance the individual versus over energy use. This chart considers both electric and gas use (gas heating converted to kWh equivalent).



This chart points out how significant natural gas is to the energy used at St. James. Over 88% of the energy consumed is space heating and domestic water heating. Since the church mini-split heat pumps are used only nominally for heating, and both the church and rectory use gas boilers for space heating and gas water heaters for domestic water heating, this equates to natural gas use, with its less expensive energy and higher greenhouse gas emissions.

The relatively low contribution of cooling to overall energy use is due to its intermittent use schedule, low occupancy rates in both the church and rectory, and the very high efficiency of these units. The opportunity for using these units for more and the boilers for less is a significant opportunity for greenhouse gas emissions reduction.

Appliances make a small contribution to overall energy use. They have significant consumption, but it is brief.

Lighting is the lowest energy consumer due to modest lighting fixtures and the virtually exclusive use of LEDs and CFLs.

To examine the opportunities for greenhouse gas emission reductions, it is best to address the largest energy consumers first. Smaller gains of these consumers would have a greater impact unless the smaller energy consumer improvements were substantial. The report will proceed starting with the largest consumers and continue to the smaller contributors. Ultimately, through examination of each of the areas, a set of improvements, or Environmental Conservation Measures (ECM) will be identified and quantified in their value to reduce St. James' greenhouse gas emission. That value is evaluated by cost versus benefit.

Space Heating

Heating efficiency is a function of the efficiency of the heating device and the relative heat losses from the space that is being heated. Together, they determine heating efficiency. Both of these factors are not efficient at St. James. The current boilers have efficiencies on the low end of what is currently available. More important, the church is only insulated in the roof of the overcroft (office) and the rectory is only insulated in the attic. Insulation affects both heating and cooling; so improving insulation will reduce energy use and greenhouse gas emissions, with an increasing effect if operating hours increase.

Building Envelope

Critical to reducing the energy needed to maintain comfortable buildings, is reducing the rate of heat loss. The boilers and/or heat pumps must overcome this heat loss. The less heat loss, the less energy needed for heating. If there were no heat loss, the heat from the occupants would be enough to keep everyone comfortable. Unfortunately, a building that loses no heat would have no doors and no windows and no fresh air to breath; so practicality has to be considered for functional needs and economic limitations.

Heat loss takes place from the container that is being heated. That container, or the Church and Rectory, is known as the building envelope(s). The building envelope is the boundary between the heated (or cooled) space and the unheated (or uncooled) space. Defining this boundary is very important to establishing an efficient heated (or cooled) portions of that space are not unnecessarily heated or cooled and if included do not contribute unnecessarily to the rate of heat loss. This is particularly important for a facility like a church, where different portions of the church are operated for relatively brief periods on different schedules. These portions may need to have separate building envelopes to avoid heating (or cooling) unneeded space. Access ways, such as stairs from one floor to another without sealed door separators as is the case from the rectory to the basement and from church to the undercroft.

Heat loss come from three types of transfer: convection, conduction and radiance. Convection is the most efficient heat remover and must be addressed foremost. Conduction is less effective at heat loss, but it is also very important. Radiation is also a factor, but one that is often misinterpreted and has led to ineffective approaches to building envelopes. Radiation will not be considered in this report.

Air Sealing

The most important heat loss is due to convection. This loss comes from air movement through the building envelope. Heat transfer is at its most efficient with flowing air, and flowing air usually also means the transfer of that conditioned air (heated or cooled to desired temperature) out of the building envelope and replacing it with unconditioned air. Air is drawn in air from wherever it has access. This heat loss comes from open windows and doors, but also from the accumulation of holes in the building envelope, such as gaps remaining even after doors are closed, poorly sealed windows, holes where electric wires, pipes or ducts run through the walls and ceiling, etc.

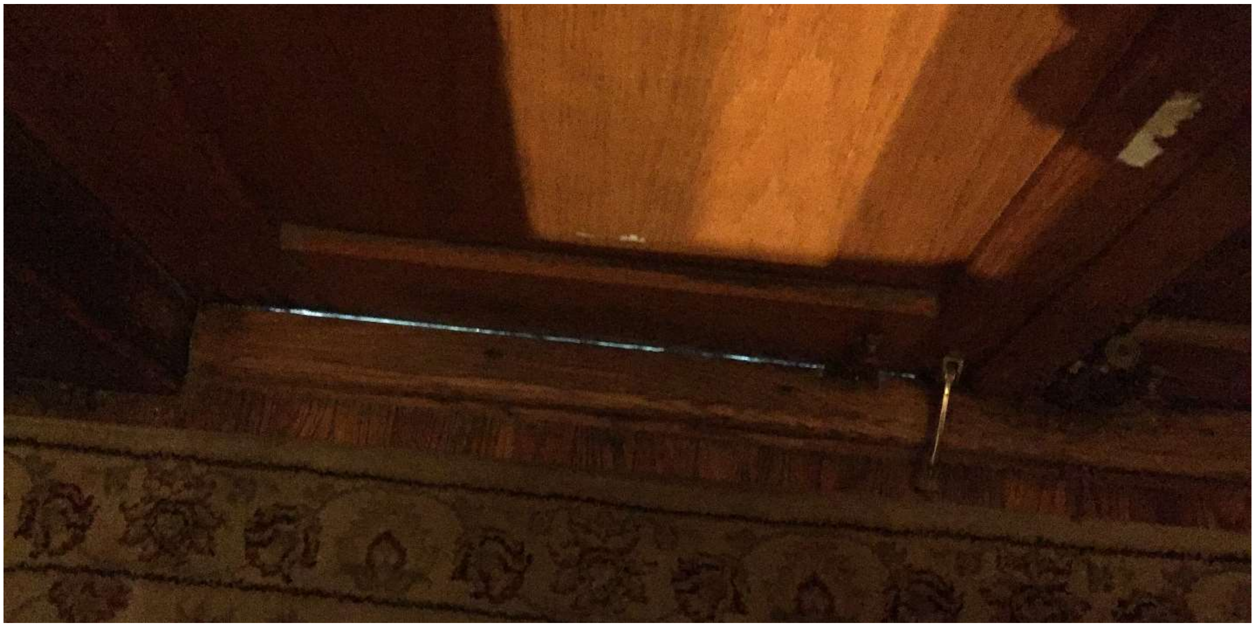
Typical buildings have enough holes to be the equivalent of a full size window which remains open through winter and summer. The St. James church and rectory are not exceptions.

Air conditioning duct in 2nd floor of rectory going to attic

It is important that the air sealing be addressed before the insulation is installed when it is easier to locate and does not get masked by insulation that is only doing a portion of the air sealing role. If air sealing is not done, then the effectiveness of the insulation will be diminished. The most critical air sealing prior to insulation application is where there are wall penetrations and gaps at building joints. This air sealing will reduce the preparation and mess with any blown in insulation.

The best way to quantify and locate air leaks is to perform a blower door test. The blower door test is a means for pressurizing the building to exaggerate air leakage that also quantifies the level of leakage. While the building is pressurized, the technician does a detailed survey of the building using smoke sticks to make the air flow visible at the points of leakage. A pre-test prior to air sealing helps inform where sealing is needed. The pre-test also provides a baseline for comparison to gauge how successful the air sealing efforts have been or if more needs to be done. Some contractors will do blower door tests and air sealing work; others may not. In either case, it is best to have the air sealing person on-site when the blower door test is done to gain the most input for their air sealing effort; otherwise a lot of valuable information will not have been communicated.

Other air sealing that can be done after insulating, including door and window weather stripping and door closure alignment. An example of an issue is shown in the photo of the church front doors below:



This gap in the church front door may look small, but it is equivalent to a 2"x 2" open window.

Only the rectory basement door is well sealed. The main church entrance doors, side access door and rectory front door need to be aligned with stops and weather stripped. The attic access also needs weather stripping. In addition the weather stripping, 2" of foam board should also be attached to the back of the attic access to reduce heat loss through it.

St. James uses vestibules at the main entrance and the main entrance to the undercroft. Vestibules reduce the heat loss or infiltration with the opening and closing of doors. The best sealed doors should correspond with the building envelope, that would be the inside door to the Sanctuary and the inside door for the undercroft.

Insulation

St. James is remarkable in its lack of insulation. Only the ceilings of the Rectory and Office have any insulation. Insulation provides resistance to heat loss; so the St. James Rectory and Church have little to hold in the heat generated by the boilers and mini-split heat pumps. Reducing the rate of heat loss will reduce the amount of fuel needed to maintain the heat in these two buildings, particularly if the open hours of the church are extended.

For the current operating schedule, for the temperate months, insulation is not as critical for the church, which is currently seldom occupied. For winter, the heat loss is significant in both protection from domestic water freezing and other damage from the cold and the amount of recovery needed to regain a heat level to support the activities of the building. On the other hand, the Rectory is currently more constantly occupied and heat loss plays more of a factor regardless of the season.

Ideally, all use areas of the church and rectory would be insulated with insulation to reach at least R20 on all sides and overhead. However, there are limits to how thick the insulation could be without requiring major reconstruction. In order for the insulation to be fully effective, it must be contained on all sides. Otherwise air flow around the insulation may also flow through the edges of that insulation, negating a portion of the air-trapping quality that makes it effective. Insulation uncovered can lose 30% to 50% of its effective thickness. Insulation must also fit into the insulation per its uncompressed thickness, or, again, it loses its full insulation properties. Using the cavities as they are is the most practical approach. Therefore, considering location, air flow, cavity space and available forms of insulation, the following table shows recommended insulation for the church and rectory.

The insulation type varies with the location. For example, spray foam is recommended for the basement due to the possibility of flooding. This insulation would be ideal everywhere because it has a high insulation value per unit of thickness, it does not require backing (except for fire code), and it both insulates and air seals. However, it is much more expensive and the chemicals are less environmentally friendly. There is a vegetable-based version of the spray foam that is a little more expensive but more environmentally friendly (it still requires propellants and it cannot be recycled, where sometimes some insulation can). Foam board insulates nearly as well, is more reusable, but it does not air seal around the edges and has some off-gassing. Foam board does not conform well to surface variations and other changes. Cellulite is pretty effective insulation that can be blown-in, but it will not hold up to flooding, and must be carefully managed to ensure cavities are filled. In general, it is strongly recommended that insulation be professionally installed. It would be recommended to have the spray foam quoted by space to be able to evaluate the tradeoffs with other possible insulation for those spaces.

Space	Existing Insulation	Available Cavity	Recommended R-Value	Recommended Insulation
Church Roof	None	None	20	Foam Board
Church walls	None	3.5"	13	Cellulose blown-in
Overcroft ceiling	R19	5.5"	19	No change
Undercroft walls and Rim Joists	None	12"+	13	Spray Foam
Undercroft ceiling	None	3.5”	13	Fiberglass batt
Rectory Ceiling	R30	12"+	30	Re-use existing
Rectory walls	None	3.5"	13	Cellulose blown-in
Basement walls	None	None	11	Spray Foam or Foam Board
Basement Rim Joist	None	4"+	11	Spray Foam or Foam Board

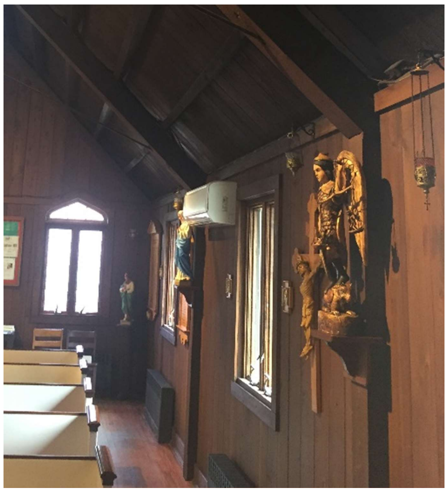
The church roof is the most difficult to insulate in order to maintain both structural integrity and aesthetics. There are two approaches: insulate below the ceiling boards; or insulate under the roof. Under the roof is the ideal location to insulate because a continuous layer can be added without interruptions for beams. However, adding that insulation requires re-roofing the church, which is a significant expense and disruption. If the current roof were in poor shape, then this would be an excellent joint project to add the insulation and replace the roof. Adding insulation and replacing a sound roof is more controversial. However, adding insulation and replacing the roof is probably less costly than the detail work required for insulating from the inside, which would also be aesthetically controversial (but actually could be a good excuse for making a lighter colored ceiling, which would take less energy to light and might be more aesthetically pleasing). Insulating from the inside is discontinuous, with gaps for every horizontal structural beam where a thermal bridge between the outside and the inside reduces the effectiveness of the insulation; so it will be a little less effective.

Adding insulation to the outside consists of adding sheets of foam board (ideally 4 inches) over the ceiling boards, adding another layer of plywood to hold the new shingles, and adding roofing paper (this is trending towards Tyvek®-type breathable roofing paper), and then the shingles. Fasteners for the outer layer of plywood must be carefully selected to ensure structural integrity of the assembly. If the roof is redone this is also an opportunity to consider two other opportunities: lighter color roofing to reduce heat absorption; and alternate materials, such as metal that are more environmentally-friendly (metal roofs last much longer and the materials are recyclable versus composite shingles, and they absorb less heat). An alternative to the foam board is Structural Integrated Panels (SIP) which are manufactured panels made from outside layers of strand board with foam insulation sandwiched between. The panels have excellent structural properties, form better seams than the foam board and can be purchased in variety of thicknesses to obtained the desired level of insulation. Unfortunately, they are also expensive and have long lead times.

Adding insulation on the inside involves fitting foam board between the horizontal tie beams with a total of 4 inches of foam board, and then covering that foam board with drywall for aesthetics and fire safety. The foam board should be caulked on all sides before adding the drywall to ensure moisture is not trapped next to the wood.

It is recommended that both approaches be pursued with multiple vendors. Neither project is common, and each will require someone with experience with the particular solution. Quotes will vary significantly, and vendors should provide locations that can be visited where they have performed similar work.

Church and Rectory Walls.
The church and rectory walls have no insulation. There is an air cavity where insulation can be blown-in. In both cases, cellulose would be the best environmental, cost-effective, and insulation-effective choice. The only downside is that it would be ruined in the event of flooding. Spray foam would be the more resilient solution at the expense of the environment and cost.



Church interior wall (left). **Rectory wall cavity as seen from attic in rectory**

For the rectory, the best access is from the attic, which avoids drilling into the walls. Some or all of the wall cavities have horizontal cross beams (which they should have for fire code) and will require inside drilling below those cross beams to blow in the insulation. Basement access may be helpful; so the walls should be insulated before the rim joist is insulated.

For the church to avoid plugs in the interior paneling, it may be possible to remove one panel for every one or two studs for use in filling that stud cavity and adjacent stud cavities that can be accessed by drilling adjacent studs through access from the removed panel.

Church Undercroft
The church undercroft can be insulated on the inside behind the finished walls in the meeting room using spray foam. Spray foam would survive the best in the event of a flood. The spray foam also conforms to wall variations, such as the structural columns formed in the concrete foundation and any concrete imperfections. Due to the length of the wall, access holes through the finished will be required. It would be better to insulate at the concrete, rather than at the finished wall because the latter would result in a gap between the undercroft inside wall and the church outside wall at the undercroft ceiling.

The spray foam insulation needs to extend into the rim joist of the church to be sure this vital area is sealed and insulated.

Rectory Basement

The rectory also needs foam insulation to survive the best in the event of flood. The rectory basement can use spray foam or foam board, since it is exposed and will probably remain unfinished. The foam needs to either be fire retardant or be covered in drywall or equivalent to provide that fire protection. There are integrated basement finishes that can be considered, but generally the cost and quality (and flood survivability) suffer.

Rectory Basement Rim Joist

The rectory sits on a flooring system that rests on the basement concrete walls with perimeter beams called rim joists. This area is often left uninsulated and often is not well air sealed. Complete basement insulation should include the rim joist, using either spray foam or foam board pressed into the joist pocket and caulked. Since the basement is below ground and the rim joist is above ground and of a location that is frequently penetrated with utility wires, pipes, etc., it is actually the most important part of the basement to insulate. Towards the bottom of the basement wall has diminishing insulation value due to the relatively constant temperature of the earth.

1) Rectory basement showing joists where they meet foundation wall;2) last joist on the end, running along foundation; 3) rim joint pocket between joists at wall (concrete basement wall at bottom)

Church Undercroft ceiling

The undercroft does not need to be insulated from the Sanctuary if it is insulated along the walls (it would be hard to isolate the stairs for separate building envelopes). Nominal insulation would allow more separation of the spaces due to their different use schedules and provide noise insulation if their schedules did coincide. There is not much space to put in insulation and it houses lights that must be occasionally (though rarely) serviced. Another approach is more insulated ceiling tiles.

Rectory Ceiling

The rectory ceiling has R30 fiberglass batt insulation. The insulation itself is in functional condition, but it is “faced” insulation, with integral tar paper on one side. Faced insulation is not appropriate for attics (or really anywhere else) because it blocks water vapor from escaping through the ceiling. The vapor barrier needs to be at the ceiling (by carefully sealing all wiring penetrations, duct penetrations, etc. and maintaining a continuous painted surface) and any vapor getting through the ceiling needs to be released. The facing acts as a condensation plane, trapping the moisture next to the joists and the ceiling. This facing can be carefully peeled to minimize insulation loss, which is the first step to the next, which is to better fit the insulation to ensure all cavities are snugly filled and the remaining 3 inches extend above the joists without compacting. The uncovered joists should then be covered with R13 batt insulation cut into 2" strips so there is a continuous insulation blanket across the ceiling. Blocks at less than two foot intervals need to support a pair of 8 inch access planks (similar to shown below) for service personnel to walk on to get to the air handler located in the attic without stepping on the insulation and breaking through the ceiling. The goal is a continuous insulation blanket with a safe clear service path. This insulation work should be done after the walls of the rectory are insulated unless wall insulation does not end up requiring attic access to the walls.

Space Heaters

Space heating needs both heat containment and heat generation. Boilers are the primary source of heat generation for the church and rectory. The boilers both needed to be replaced in 2013 as a result of Sandy. Unfortunately, the replacement boilers are not particularly efficient. The church boiler is 82% efficient (200,000 BTU/H capacity) and the rectory boiler is 80% (77,000 BTU/H capacity). More efficient boilers approach 95% efficiency.

Further, the boilers are the major user of natural gas and with it, greenhouse gas emissions. The Long Beach climate, however, is listed as sub-tropical, well within the operating range of heat pumps, which use the slightly or very much cleaner electricity (depending on source selection) and operate at efficiencies exceeding 1000% (COP of 10.7). The mini-split form of heating, even including the premium paid for electricity versus gas, has a net overall heating cost reduction of over 2.3 times.

The good news is that St. James already has the tools to begin lowering its greenhouse gas emissions. These tools are the existing mini-split units in the church. Rather than using the boiler to heat, the mini-splits can be used to heat particular areas just as they are currently used to cool those spaces. The heat on the boiler should be set to a low temperature, such as 40 degrees or lower so that it only comes on to heat when it is close to freezing. Using the boiler provides a backup and protection for water pipes until confidence and capabilities allow the boilers to be disconnected altogether.

For heating, the experience of St. James has been positive with the Fujitsu units, but not positive with the Samsung units. The Samsung units are rated to 5°F degrees while the Fujistu units are rated to 0°F. While the minimum temperature is different, this should not account for this difference in perception. The reason hypothesized is that the Samsung units have 1/3 of the capacity of the Sanctuary units in about the same amount of floor space. While the basement is inherently better insulated (because it is underground) and has much lower ceilings, the capacity of these units appears to be small by typical rules of thumb (300 square feet per ton or 78,000 BTU/H for the floor area). As supplemental air conditioning in an already earth-cooled basement, the sizing is fine, but inadequate if being used for heating.

The boiler in the rectory can also be replaced by replacing the existing air conditioner with a larger heat (52,000 BTU/H vs 30,000 BTU/H) pump since the duct work is already in place. Since the first floor duct registers are in the ceiling of the first floor and the heat is being pushed down from the attic air handler, this solution is less efficient and effective for heating than would be ideal. A better solution would involve adding ducting and a second air handler in the basement. That way, the existing attic air handler could be left as-is. A balancing valve between upper and lower would allow the system to be nicely tuned for optimum winter and summer performance with relative flows to the upper and lower air handlers. Alternative supplemental heating sources are described below.

Solar Space Heating

Both the rectory and church boilers have distribution systems that could alternatively be provided with Solar Thermal as the heat source. Solar Thermal space heaters use evacuated tube arrays in roof-mounted panels to heat glycol to 160 degrees, which is hot enough for space heating. These systems are seen worldwide, but are not particularly popular in the United States (system shown is in Indonesia). Due to their lack of market penetration, Solar Thermal space heaters, are probably not viable for a church due to the need for an available and strongly interested caretaker. Hopefully, this market will develop at some point; so it is recommended that even if the boilers are removed, the hydronic heat distribution system of valves, pipes and registers be left in place. An alternate to the evacuated tubes are traditional solar thermal panels more popular in the U.S historically. Their temperature gains make them a little more marginal for this application in this climate, but worth quoting as an alternate.

For supplemental space heating, there is a product from Canada called CanSolAir. This device has a solar collector size panel that is mounted vertically on the wall of a building to warm the air in a room. It has an inlet duct at the bottom that comes through the wall of a room and an upper duct that discharges warm air when the duct is open. The system uses a fan to distribute the heat room-wide (system shown is in Nazareth, PA). This panel needs to be located on the south side or back of the rectory and/or church. It can provide heat throughout the year. Unfortunately, it can only be used as supplementary air, and it varies with weather conditions; so it can't be counted on as a primary heat source.

Domestic Water Heating

The second biggest user of energy also uses natural gas. Water heaters are located in both the church and rectory. It is likely that the hot water demand in the church is very small – only for cooking, cleaning and hand washing. The hot water demand is also very intermittent. Currently 80 gallons of standby hot water sits idle, requiring supplements of natural gas combustion to remain ready.

The water heating functions in the church would be better served by an inline or "instant" water heater. Unfortunately, effective inline water heaters use natural gas. While there would be significant energy savings, natural gas would still be in use.

The biggest consumer of hot water is probably hand dish washing. Hand dish washing does require hot water, as much as 30 gallons or more, depending on who is washing what and at what temperature. However, this demand can be managed through both technology and operational improvements. The amount of flow from the faucet is both a technical requirement to process surfactant suspended organic matter and a psychological perception as interpreted by the dish washer. To address the psychological factor, a lower flow sink faucet is recommended. The Water Sense recommendation is 2.2 gallons per minute (gpm). Kitchen sink faucets are not required to label the maximum flow, but many now do. Replacing the kitchen sink with a 2.2 gpm or less faucet will reduce the hot water consumption. Also, a card placed by the sink can encourage dish washers to save hot water and the planet by not leaving the water running continuously while washing dishes.

It is important to test the existing kitchen faucet for two reasons: to determine if it actually needs to be replaced and to get a baseline for comparing future water measures to gauge existing and then future hot water storage requirements. To test the existing faucet, use a half-gallon or similar marked container and time the length of time it takes to fill (most Smart Phones have a stop-watch function that can be used). Start the flow, place the container under the faucet and start the timer. When the line is reached, stop the timer. Divide the time into fractions of a minute and divide the container amount (in fractions of a gallon) by the time in fractions of a minute to get the flow per minute.

General cleaning may consume significant amounts of water. Consumption depends upon frequency and cleaning style. One way to address this consumption is to express the objective to save hot water with cleaning personnel for ways to reduce hot water usage while retaining satisfactory sanitation. Water is an exceptional solvent and the most environmentally friendly. Switching to alternate cleaners would save hot water but consume resources and probably result in more harm to the planet, although I have not located evidence to support this assumption.

The next biggest consumer is the dishwasher, which has water pre-heat functionality; so it does not need a hot water supply. The pre-heat function only slows the run cycle a little. Using the dishwasher to wash a larger percentage of dish washing will save significant amounts of hot water.

Hand washing is the next biggest consumer of hot water. Hand washing has similar psychological and technical issues to hand dish washing. Water Sense water faucets should replace the existing faucets. Water Sense requires a maximum of 1.5 gpm. Excellent Bathroom sink faucets are available in 1 gpm maximum flow. Psychologically, it may be helpful to post a card indicating the need to reduce the use of hot water for the planet and to suggest that cooler water is actually gentler on the skin, leading to less breakdown in its ability to defend itself from biological agents. The existing faucets should be tested at full flow as was recommended for the kitchen faucet to get a baseline and base improvements.

By reducing water use in the church, the need for an 80 gallon water heater diminishes. Once it reaches the 40 gallon point (a comparison of the existing kitchen and bathroom flows versus improved flows will provide a rough gauge), an alternative to the natural gas water heater can be considered. The gas water heater is approximately 80% efficient. Converting to an electric water heater would increase that efficiency to 100%, but increase energy costs tenfold. Converting to an electric heat pump water heater with a COP of 3.1 (which can be thought of as 310% efficiency) will increase the energy cost only three-fold while removing the emissions from natural gas from the St. James inventory.

Heat Pump Water Heater. Heat pump is black colored area on top (also note, electrical feed is to top, making it somewhat flood resistant, although only part way up. A feature of the heat pump water heater is a control panel which allows for different levels of efficiency versus types of demand and also a "Vacation mode" where the heater relaxes its heating and then ramp back at the end of "vacation." Vacation mode allows the water heater to be used intermittently to easily schedule to save energy during times of non-use. In some parts of the country, either the heat pump water heater or a substantially more insulated water heater are required in new and replacement situations. This regulation has helped develop the market for these types of products.

Since the rectory uses a 40 gallon tank now, the heat pump water heater can immediately replace the gas water heater.

Another alternative for hot water supply is Solar Hot Water using panels on the roof to harvest solar energy. These systems are very effective, even in northern climates, although usually they need some form of backup in the winter and sometimes in the fall or spring. The biggest problem is lack of local demand, making systems hard to purchase, install and maintain. Reliable systems are dependent upon the system owner and not a full-service contractor (because they are not available). The systems are also dependent upon outdoor plumbing, which if not done well, create problems in an environment which can have intermittent freezing. Solar hot water is compatible with heat pump water heaters such that the solar hot water system pre-heats the supply water to the heat pump water heater, reducing the energy needed to warm the water.

Another alternative considered was to combine the water heaters for the church and rectory. The two are closely spaced together and the church needs are typically in the morning (but not early), while rectory needs are likely typically at night and first thing in the morning. This combination might work under the present schedule, but if occupancy conditions change conflict might lead to future difficulties. This option should be considered as conditions change. If solar hot water were to be introduced, the systems should likely be shared. At that time the extra plumbing required to bring the systems together would just be part of a larger plumbing project.

Space Cooling

Space cooling of St. James is accomplished through the mini-split units for the church and a traditional air conditioner for the rectory. The cooling for the church is the most efficient, environmentally-friendly available for the Long Island climate. The 17.5 SEER Fujitsu units is best in class. The Samsung 16 SEER is not far behind. The Samsung units lack enough heating capacity for the undercroft. Replacing these units with higher capacity (BTU/H) units will not help cooling because excess capacity does not equate to more effective or efficient cooling; it actually decreases it, depending on the extent of over-capacity relative to the current weather conditions. A replacement that has two separate systems rather than two indoor and one outdoor unit may be preferable to allowing number of units running, and therefore capacity, to vary. These questions would be best answered during the investigation of resizing and replacement options.

The 13 SEER rectory air conditioner is on the high end of conventional air conditioners. There are high-efficiency models with two-stage or scroll-type compressors that operate at 16 to 18 SEER. With the migration to non-fossil fuel heating, heat pump options have similar SEER ratings.

Space cooling, like space heating, depends on the both the efficiency of the unit and resistance to heat loss from the space. The air sealing and insulation improvements are critical for space cooling as well.

Rectory attic air handler with insulated ductwork serving the second and first floor of the rectory

Appliances

St. James does not have a lot of appliances and the appliances do not appear to be heavily used. Without logging energy use on each appliance, the relative contribution of each appliance is indeterminate. This could be studied in more detail, but use will vary from individual to individual; so this data would not generally yield useful data. However, from an emissions perspective, the appliances of most concern are the gas stoves in the church and rectory kitchens and dryer in the rectory. From a resource perspective, the biggest consumers are the refrigerators because they operate 24 hours/day, 365 days/year. Other appliances addressed include the washing machine, dehumidifier, and dishwashers.

Gas Stoves

The gas stoves, or ranges, with gas ovens in the church and rectory kitchens are efficient from a combustion standpoint (about 80%). However, electric stoves and ovens are a little more efficient (100%), just more costly for St. James to operate. Numerous studies of the performance of modern electric ranges have shown them to boil water as rapidly as gas ranges. While there is not a huge gain in efficiency, the ranges are not used very much, the significant increase in energy cost and the capital cost of these expensive appliances, makes replacement a lower priority. They should be replaced as the de-gasification of St. James gets close to completion.

Gas Dryer

The gas dryer is pretty efficient, like the gas stoves. Depending on the number of loads per week, this appliance is probably not a major contributor to St. James greenhouse gas emissions versus other appliances. It does however use 22,000 BTU/H which is a little more than half of that of the water heaters. It also draws 720 Watts at peak (average is about 500 Watts) of electric power to rotate the drum.

An alternate dryer that should be coming on the market in the next few years is a heat pump electric dryer. The heat pump dryer will yield similar efficiencies as the heat pump water heater, making this conversion more attractive when they become available.

Washing Machine

The washing machine in the rectory is an inefficient, top loader style. This style has three disadvantages: it uses more water than it needs to; it uses more power than it needs to; and it leaves the clothes wetter upon completion, which causes the dryer to use more energy. Front loader style and newer top loader models would save at least half the energy it uses and reduce the dryer energy close to the same. It would also save hot water if warm or hot water washes are run. The washer is likely not frequently used and it is expensive to replace; so while it would be environmentally helpful to replace, it is hard to justify before it reaches end of life, but it should be considered as circumstances change.

Refrigerator

The refrigerator in the rectory kitchen, the Amana model BRD18V1W, is not as efficient as more recent refrigerators, but more recent refrigerators are not dramatically more efficient; so capital versus improvement is a long payback. Case in point, the newer (2018) church LG refrigerator has the same peak power use for a little bigger nicer refrigerator. On average, it will use less energy than the older Amana, but not a lot. The church refrigerator LG model 50UK6500AUA is not an efficient design for the less accustomed user because one cannot see enough of the interior with one door open to avoid opening the second door. For the accustomed user, the reduced area open with one door reduces the cold air falling out that happens with a single larger door. Both refrigerators have bottom freezers, the more efficient design configuration.

Because the church refrigerator may be used less often and may not contain many frozen items, it would be helpful to put containers of water in the freezer to reduce refrigeration cycling. These containers would then be taken out when more freezer space is needed.

Dishwashers

The dishwashers in both the church and rectory are ENERGY STAR certified. This is an important certification that indicates that they are likely much more energy efficient than non-rated models. Dishwashers save energy due to their water management versus hand washing. Dishwashing soaps should be selected for minimal impact to the environment, such as 7th Generation or similar.

Dehumidifier

The dehumidifier in the basement of the rectory is needed to protect items stored in the basement from mold and mildew. It is really only effective and needed during the summer conditions, and it runs intermittently but regularly throughout the summer months. It draws about 50 watts. It should be run at a particular humidity setting rather than on continuous mode, both to reduce energy use and increase the dehumidifier's life. ENERGY STAR dehumidifiers are recommended when it needs to be replaced.

Air Handler

The rectory attic air handler is basically a fan with a heat exchanger from the compressor coolant lines. The fan can be made more efficient by exchanging the current ¼ HP motor with a more efficient ECM (Electronic Commuting Motor). Some HVAC service personnel are equipped to perform this update; but many are unfamiliar with it. It is an opportunity to reduce the motor electric use by about half, but it should not be undertaken by someone unfamiliar with ECMs because the mounting method can be incompatible or require adjustment.

Ventilation

Ventilation plays a big part in removing toxins and/or contributors to toxins from the indoor environment, including humid air from bathrooms that can lead to mildew and mold, and kitchen stove combustion exhaust and humidity. The removal of air from the exhaust fans also creates additional draw for fresh oxygenated air from outside to replace the higher carbon dioxide and water vapor content air inside generated by people. Like the air handler, ECM (motors) improve the efficiency of these ventilation devices and will reduce electric use. Like the air handler, match form, size and mounting make them potentially complicated to upgrade.

The overcroft has an exhaust fan in the ceiling that was useful prior to the addition of the mini-split air conditioner. Now it is a detriment to keeping this room cool when not in active use as the sole means of cooling this space. It is always a detriment to keeping this space warm.

Overcroft ventilation fan detail and context (courtesy of WC Keller)

To reduce the energy loss from this fan, a swinging door can be made to open against the inside wall of the dormer when using the fan. The swinging door when closed should fit against perimeter molding and have weather stripping to provide an excellent seal when it is closed. The top of the swinging door should have foam board insulation to reduce heat loss through the swinging door when it is closed. THe fan can be useful to purge hot air in the office space or for circulation on nice days.

The bathrooms in the church did not appear to have exhaust fans. They are not required for bathrooms without shower or baths and remove conditioned air from the space. From a ventilation standpoint, they are advised, but may not be necessary.

The bathroom in the rectory did not appear to have an exhaust fan. If it does, it could be made more efficient. If it vents to the attic, it the ducting should be directed out the roof. Panasonic makes ECM bathroom exhaust fans that are particularly efficient and quiet. The Panasonic fans use an average of 7 to 10 watts versus 40 to 50 watts for typical construction grade bathroom fans.

The ceiling fans in each of the bedrooms do not ventilate and just recirculate air, enhancing evaporation to help cool individuals in the summer, and bringing heat lower in the room in winter. These fans are heavy inertia fans and run at relatively low wattage draws for the size motor. The most important operating recommendation is to only operate fans when someone is in the room with the fan or adjacent to the room with the fan such that they are receiving the evaporative benefit. The fans perform only a local function and do not aid the rest of the rectory. The only reason to leave a fan on when leaving its space is when one is planning to return in 5 minutes or less so that a motor startup is avoided. Otherwise, these fans are often left on and not usefully run as a wishful effort to improve comfort in other areas.

The exhaust fans located under the microwave units in the rectory and church kitchens do not vent outdoors. This is not ideal from an air quality standpoint especially with gas ranges. Vented exhaust fans would be more efficient and effective (safer) than opening windows to exhaust cooking.

Lighting

St. James caretakers have been diligent about updating lights to Compact Fluorescent Lamps (CFL) and later to Light Emitting Diode (LED) lamps. The undercroft ceiling lights are both an aesthetic and efficiency milestone. However, some lamps have not been upgraded and should be immediately.

CFLs are much more efficient than incandescent lamps (about 75% more efficient, using about ¼ of the energy); though typically not dimmable like incandescent most standard bulbs. This efficiency is important because lights are used for prolonged periods so the energy use adds up. LEDs are almost twice as efficient as CFLs and have the advantage of coming to full brightness much more quickly, are usually dimmable (though that feature always needs to be verified on the packaging if that functionality is needed) and usually quieter. Also, LEDs use so little energy compared to incandescent lamps that older dimmers may not be compatible, requiring new dimmer controls. Generally, it is always worthwhile (the payback is typically months, not years) to upgrade from CFL to LED to improve performance and safety (CFLs contain mercury and need to be properly recycled at cooperating retail locations or through municipal programs). Exposed CFLs are a safety risk it run into.

This incompatibility with existing dimmers can make kitchen exhaust fan upgrades to LED problematic. The kitchen exhaust fan in the church fan does not appear to dim and can be upgraded; the rectory exhaust fan appeared to have dimmer control; so an upgrade may or may not work. Both should be upgraded, but checked to verify proper operation.

Inside Lights

The lamps needing to be upgraded include the following:

- Overcroft lights used to light the stained glass window in the Sanctuary. These lights are incandescent are regularly used for service. There are also two overcroft ceiling lights, one of which is incandescent and the other CFL. Replacing all five with LEDs is recommended.

- The rectory entryway is a 60W incandescent lamp that can take the current LED model used elsewhere. Since these existing LEDs only illuminate from the exposed end of the bulb, which works fine for this location, it can be taken from a bedroom table lamp where newer bulbs (such as EcoSmart from Home Depot) with no directional orientation would serve better.
- The church undercroft basement is a 60W incandescent, but it used infrequently, reducing its priority. However, if this light were left on, the energy consumed becomes more significant. Changing it to LED using another LED being upgraded for better performance would be a good candidate for this location.
- There are multiple ceiling fixtures with glass shades that were not removed to establish the type of lamp(s) inside (basement kitchen, basement hall, stairs to Sacristy, and undercroft restrooms. These are likely mostly CFLs that can be upgraded to LEDs.
- The rectory bedroom fan lights were not checked as to the bulb type. From other lamps sampled, they are likely LEDs, but should be checked.
- The church kitchen has three fixtures with four T8 fluorescent lamps per fixture that can be replaced with equivalent LED lamps that will reduce the energy use by half. This is a commonly used space; so the improvement is definitely worth the effort. If the LEDs selected are “direct-wired” or “ballast bypass,” the existing fluorescent ballast can be removed to remove a potential failure point and potential noise source. Below is a general description of the LED fluorescent replacement options.

  The LED replacements for the fluorescent lamps come in two types: plug n’ play (type A), which uses the existing ballast such that only the fluorescent lamps are replaced; or direct wired (type B), which eliminates the ballast and wires the lamps direct to power, like an incandescent lamp. The advantage of the plug n’ play is that fixtures can be retrofit on a fixture by fixture basis. The disadvantage is that a potential failure point and additional component, the ballast, has to be maintained in the fixture. So when the ballast wears out, it has to be replaced. When that happens, the ballast will be more obsolete and less available. The advantage of the direct wire, is that the ballast is eliminated and the fixture is simplified. The disadvantage is that personnel must be careful not to put a fluorescent tube in an upgraded fixture because the fluorescent lamp will be unstable without the ballast and could short or potentially result in a fire in that fixture. Industry practice is to label the fixture once it has been converted, but it still relies on caretaker personnel reading the label and not making a mistake with a fixture with connections that could accept either lamp.

- Only one Exit sign was noted. It is in the undercroft at the front entrance, under the front entrance to the Sanctuary. This Exit sign appeared to be LED, which would provide the least wattage to fulfill the function. The LED Exit signs significantly reduced the electricity consumed by these 24 hour-all year lights. The Exit light seen is older and looked like it is LED, but it should be confirmed because otherwise it could be one of the larger energy consumers in the church.
- There is a light string on the rectory porch which was not tested for wattage. This string may be LED, but it looks more likely to be incandescent. If these lights are used and they are incandescent they should be upgraded to LED. They can be tested with a kilowatt meter.

The Sanctuary LED candelabra lights are upwardly directed type lamps, which reduces their illumination below. In the rectory dining room, these candelabra lights are symmetric up and down directed LEDs. Both are the same wattage. St. James caretakers might want to try the rectory dining room lights in the Sanctuary to improve the aesthetics and improve the lighting distribution in the Sanctuary.


Lights operating also heat the space in which they are operating. Using more efficient lights and turning lights off reduces the air conditioning load; so the lamp wattage savings is compounded. For one extreme conditioning example, the refrigerator lights can be easily and cost effectively upgraded to LEDs. However, since these lights are only on when the door is open, the savings will be small. Because of the LED upgrades, light generated heat is not an issue at St. James.

Outside Lights

The outside lights typically operate on average 12 hours/day, 365 days per year. Most of the St. James outside lights are LED, including the flag pole light, the lights projecting from the rectory porch, the porch light and the carriage lights to either side of the main entrance to the church and the side entrance by the Sacristy.

Lighting Controls

The biggest percentage improvement can be made by turning off lights that are not in use, either through improved procedures, timers or occupancy sensors. The greatest savings come from the lights that consume the most energy.

Lighting can be controlled on timers, sensing an “occupant” in the room known as an occupancy sensor, daylight sensing, triggered by doors, or remote/scheduled control with a Building Automation System (BAS) or more basic equivalent. Generally, occupancy sensors do not appear necessary at St. James. Locations for consideration include the undercroft basement, church restrooms (which must work well) and church hallways. The porch of the rectory could be on an occupancy sensor or run on timer, depending on security needs.

Miscellaneous

There are many energy loads in St. James that contribute to miscellaneous energy use. These include all plug loads throughout the facility.

The TV used in the undercroft is not as efficient as lower resolution models. It uses a 130 watts when it could be using 50 watts for its size. This difference is likely due to it being UHD (Ultra High Definition). If that resolution is not needed and this TV is used often, then energy could be saved, if appropriate, by replacing it with a lower resolution version.

Office Equipment

St. James has very little office equipment: a printer in the overcroft and possibly a copier that was missed. A printer was in a bedroom of the rectory. Below is advice when considering office equipment.

The office equipment, such as copier, fax machine, etc. should be ENERGY STAR certified. ENERGY STAR office equipment has been shown to be more efficient. Not all types of office appliances are certified. Refer to the ENERGY STAR website.

Office equipment over the last several years has reduced its energy requirements through two means: reduced processor energy and reduced-energy sleep-modes. Any new office equipment purchased or leased should consume less energy than its predecessor.

ENERGY STAR® has been a strong influence for the more common office equipment. While an ENERGY STAR certification does not guarantee reduced energy use, it is very likely to. In addition, ENERGY STAR products are likely to operate more reliably and have better support due to the time and expense to be certified, which typically results in better warranty support and a more proven product.

With current office equipment, the sleep mode generally uses much less energy than used in operation. Therefore, many devices, such as copiers and postage machines can be left on all the time. If a device is more than 10 years old, the sleep mode is likely to consume closer to the devices' operating energy consumption. These devices should generally be turned off at night.

It can be beneficial to evaluate the age of existing copiers and other office equipment that is leased and have this equipment updated. The leasing costs may not go up (sometimes they go down as a result of getting a new unit), operating cost will be reduced and generally more features will be included with the new device.

Workstation computers are can be left on at night. In many cases, it is better to turn the workstations off for multiple reasons: to allow the operating system to reboot and clear its memory leaks; to improve security (unless needed for remote access); to reduce exposure to voltage peaks or drops; and to save energy. The computer does not need its monitor left on. A monitor may use almost as much energy as the computer and does not benefit from being left on any more than a room light. The extra operating hours only shortens the useful life of the device. A monitor should be turned off whenever a person is not actively using it.

Operational Energy Saving Opportunities

Operational energy saving opportunities are considered "no cost" and do not involve purchasing equipment.   They can provide significant energy reductions.

The most important operational improvement is to turn down the thermostats on the boiler in the church and heat the undercroft with the existing heat pumps whenever possible.

Other small changes include:

- Maintaining ice in church kitchen freezer when not filled with food
- Sign in church kitchen to conserve (hot) water for the planet during hand dish washing

Low Cost Energy Saving Opportunities

There are many low cost energy saving opportunities. Most of them involve LED lighting and EC Motor upgrades:

Lighting Upgrades

- Overcroft lights that light the Sanctuary window and the can lights in the ceiling
- Rectory entry incandescent to LED (use from upstairs bedroom and replace one of those lamps)
- Church Closet Hallway incandescent to LED (use from upstairs bedroom and replace one of those lamps)
- Other lights as listed in the Lighting section of this report

Hot Water Upgrades

- Kitchen sink faucets to Water Sense faucets
- Restroom sink faucets to Water Sense faucets
- Gas Domestic Water Heaters to electric Heat Pump water heaters

Energy Reduction Summary

In addition to the recommendations in each section of this report, Environmental Conservation Measures (ECM) provides a list of the recommended savings broken out by item with the savings in energy reduction associated with that ECM along with an estimated cost to implement that energy reduction and the time it would take to payback the improvement in energy savings. In addition, there is a field for other benefits because many upgrades not only save energy but improve the working environment or provide other benefits. The ECMs are sequenced in order of least to most time to pay back the change through energy saving.

It is important to note that the choice of improvements in the areas recommended is dependent upon church scheduling plans. Upgrades may not benefit if the functions where those items are applied are discontinued. On the other hand, energy is a significant concern that is likely to increase. An improvement may justify itself before the change comes about, and if that change is delayed, the ECM continues to save energy.

Some energy reductions are difficult to establish a cost and payback without more engineering design or analysis. These recommendations are covered in the function sections but not on the ECM list because they cannot yet be quantified. These recommendations are also important and in some cases, more important to pursue than those listed in the ECM list. The next section, Next Steps, puts everything together in one action plan for St. James' consideration.

It is important to note that the recommendations are proposed for St. James' consideration. They do not represent completed design. They are based on an on-site audit, follow-up phone calls, utility bill reviews, engineering calculations and assumptions from similar but not identical facilities. Recommendations may be based on incorrect information or assumptions obtained through this process. It is not possible to fully understand all the whys and wherefores of a church such as St. James Episcopal Long Beach at this level. However, the recommendations benefit from the experience of skilled energy professionals with an outsider's fresh perspective that enable opportunities to come to the surface.

Next Steps

This ASHRAE Level 1 Energy Audit provides an overall energy assessment and recommended actions. The goal was to uncover opportunities and expose overlooked inefficiencies. With these recommended actions defined, they need to be converted into an Improvement Plan. What is needed for conversion into a plan varies by the recommendation:

1. Some recommended actions can be addressed immediately and need no further review.
2. Some recommended actions require detailed data collection and/or prototyping to define what is needed for the solution.
3. For others, it is important to first consider which other actions might be addressed and combine the efforts into a single logical project.
4. For still others, the overall strategy, based on questions raised in this report, needs to be resolved before wasting time and money on actions which do not support the overall strategy.
5. Finally, reviewing this report or portions of it with particular St. James Episcopal Long Beach personnel might lead to additional or better adapted actions to reduce energy use.

The sequence of the action plan depends on the energy saving potential, the urgency needed to mitigate an immediate concern besides energy saving and the need for data collection as prerequisite for implementing the solution.

The following **next steps** are recommended:

1. Review the report to identify any conflicts.
2. Begin addressing operation-only changes to begin saving energy and increasing the community's awareness to energy reductions. This process will uncover more potential energy saving actions.
3. Group Energy Saving Actions in logical groups for implementation in order to minimize disruption to operations.
4. Pursue needed designs and data collection for identified ECM (see Specific Actions below).

Specific Actions identified in this report:

1. Investigate PSEG Green Option suppliers to verify compatibility with St. James objectives for renewable energy generation and/or brokering.
2. Measure flow in faucets in church and rectory for maximum flow rates.
3. Locate local contractors to arrange for blower door test and air sealing to determine viable contractors and basis for them working together to transfer the blower door testing to the air sealing personnel.
4. Seek roofing contractors for insulating church roof to inform whether inside or outside applied insulation is preferable for St. James.
5. Seek spray foam contractors and cellulose contractors to establish which insulation will be used in which places to inform bidding process.

Environmental Conservation Measures

The next page lists a summary of Environmental Conservation Measures (ECM). It is important to understand the total of all the ECMs overstates the accumulated emission reductions. Each ECM is a standalone action. If combined with another ECM, the total will be more reductions, but less than the sum of two related ECMs. For example, if the lamps are upgraded in a room before a separate ECM for occupancy sensors takes place, the savings for the occupancy sensor is now based on the lower upgraded lighting wattage and not the original wattage for that space. The reductions for upgrading the lights in a space after an occupancy sensor is added will be less than the reductions when no occupancy sensor existed. For various reasons, the timing and scope of upgrades can vary; so predicting multiple upgrades would not represent the savings of any one upgrade. Reductions will need to be adjusted according to the aggregate of upgrades.

Typically there is a column for when particular actions might be triggered, which could be, for example, be a utility demand rate increase, a particular remodeling project, or when a part wears out. In St. James' case, all ECMs can and should be pursued immediately or as soon as they can be budgeted.

The greenhouse gas emissions for combustion of natural gas are based on natural gas equivalency for pipeline natural gas from EPA.gov (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references) assuming 100% combustion. The equivalency is 14.43 kg per MMBTU or **11.665 lbs. of CO_2 per Therm**.

The greenhouse gas emissions for electric consumption is based on the NY ISO fuel mix of 77% fossil fuel generation for 2020 (p.5), which for simplification are assumed to be all natural gas. New York State derives 99% of its fossil fuel electric generation from natural gas. However, efficiency of generation varies by the generation plant, which is between 35% and 40%. Using this data, New York electric supply is assumed to be **0.8175 lb per kWh**. This value compares to the national average of .92 lb. per kWh.

St. James of Jerusalem Episcopal Church See updated ECM table with breakouts **Environmental Conservation Meatures**

Item	Description	Benefit (besides energy savings)	Initial Cost	Annual Cost	CO2 Emissions Reduction (lbs)	Annual Energy Savings (kWh)	Annual Energy Savings ($)	Payback
1	Change supply to Green option	Emissions reduction	$ -	240	13,680	-	$ -	
2A	Operate Sanctuary, Sacristy and overcroft heat pumps instead of boiler	Emissions reduction (existing supply)	$ -	0	1,874	14,090	$ 780.00	
2B		Emissions reduction (green supply)	$ -	240	6,066	14,090	$ 780.00	
3	Perform air sealing of rectory and church building envelopes	More comfortable	$ 3,000	0	4,884	11,323	$ 782.11	3.84
4	Add foam board insulation and re-roof church	More comfortable	$ 24,598	0	6,007	13,928	$ 961.99	25.57
5	Add insulation to rectory, church walls	More comfortable	$ 13,907	0	5,812	13,475	$ 930.71	14.94
6	Add spray foam insulation to undercroft, rectory basement and rim joists	More comfortable	$ 15,215	0	4,965	11,512	$ 652.40	23.32
7	Correct Rectory ceiling insulation	More comfortable	$ 1,661	0	3,517	8,153	$ 462.03	3.60
8	Replace gas domestic water heaters with electric heat pump water heaters	Emissions reduction	$ 3,500		3,033	5,652	$ 1,390.41	2.52
9	Replace kitchen faucets with Water Sense faucets in church and rectory	Emissions reduction	$ 550	0	758	1,905	$ 184.50	2.98
10	Replace T8 Fluorescents with LED T8 in kitchen ceiling lights	Less bulb, ballast repl.	$ 180	0	257	339	$ 83.28	2.16
11	Replace bathroom sink faucets with Water Sense faucets in church and rectory	Emissions reduction	$ 540	0	152	381	$ 51.66	10.45
12	Replace rectory air handler motor with ECM	Quieter	$ 350	0	156	205	$ 101.01	3.46
13	Replace 5 overcroft spot lights and can lights with LEDs	Less bulb repl.	$ 100	0	62	81	$ 19.96	5.01
14	Replace rectory entry light with LED bulb	Less bulb repl.	$ 5	0	41	55	$ 13.43	0.37
15	Replace closet hallway with LED bulb	Less bulb repl.	$ 5	0	12	16	$ 3.84	1.30
			$ 63,611	**$ 480**	**45,210**	**81,114**	**$ 6,417.32**	

EMS ENVIRONMENTAL

10/4/2021

Space	Existing Insulation	Available Cavity	Recommended R-Value	Area	Recommended Insulation	Cost/Sq.Ft.	Other Costs	Total Cost
Church Roof	None	None	20 / 30	2340	Foam Board			
Church walls	None	3.5"	13	1760	Cellulose blown-in			
Overcroft ceiling	R19	5.5"	13	225	No change			
Undercroft walls	None	12"+	13	1980	Spray Foam			
Rectory Ceiling	R30	12"+	30	650	Fiberglass			
Rectory walls	None	3.5"	13	1632	Cellulose blown-in			
Basement walls	None	None	10	816	Spray Foam or Foam Board			
Basement Rim Joist	None	4"+	10	102	Spray Foam or Foam Board			
				9505				
Rectory ceiling				112.5	Remove facing, re-fit, fill gaps, add service access boards, supports. Other cost= labor)	$ 4.10	$ 1,200	$ 1,661
Church and Rectory walls				3392	Cellulose	$ 4.10		$ 13,907
Undercroft and basement walls, rim joists				2898	Spray Foam	$ 5.25		$ 15,215
Church Roof				2340	Foam Board+Plywood top and bottom (other cost=shingles)	$ 8.38	$ 5,000	$ 24,598

Service Area	Service	Unit Location	Brand	Model No.	Serial Number	Cooling Capacity (BTU-H)	Gas Input (BTU/H)	Heating Capacity (BTU-H)	Eff.	SEER	EER	HSPF	COP
Church	Space Heating	Boiler Room	U.S.Boiler Company'	Burnham Series 2			244,000	200,000	82%				
Church	Water Heating	Boiler Room	Bradford White	MI50L6FBN	JL17361245			40,000					
Sanctuary #1	Cooling, heating	Inside W	Fujitsu	ASU30RLX	JPA008302	30,600		32,000					
Sanctuary #1	Cooling, heating	Outside W	Fujitsu	AOU30RLX	JPN008764	30,600		32,000					
Sanctuary #2	Cooling, heating	Inside E F	Fujitsu	ASU30RLX		30,600		32,000		17.5	10	9.5	10.7
Sanctuary #2	Cooling, heating	Outside E S	Fujitsu	AOU30RLX		30,600		32,000					
Sanctuary #3	Cooling, heating	Inside E N	Fujitsu	ASU30RLX		30,600		32,000					
Sanctuary #3	Cooling, heating	Outside E N	Fujitsu	AOU30RLX		30,600		32,000					
Sacristy	Cooling	Inside	Fujitsu	ASU7RLF	KPA019388	7,000							
Overcroft	Cooling	Inside	Fujitsu	ASU9RLF	KQA039724	8,500		10,000					
Sacristy & Office	Cooling	Outside N	Fujitsu	AOU18RLXFZ	LTN009862	18,000		21,600					
Meeting Room	Cooling	Inside E S	Samsung	MH052FNCA		18,000		19,000					
Meeting Room	Cooling	Inside E N	Samsung	MH052FNCA		18,000		19,000		16		8	
Meeting Room	Cooling	Outside E M	Samsung	MH080FXCA4A		31,700		34,900					
Rectory	Space Heating	Basement	New Yorker	CG40CNC-TE2			96,000	77,000	80.1%				
Rectory	Water Heating	Basement	American Water Hea	BFG6140T403NOV	12427458875			40,000					
Rectory	Cooling	Outside	Rheem	13AJN30A01	8391W461211100	30,000				13			
Rectory	Cooling	Attic	Rheem	RHSL-HM3017AA	W481208193	30,000							