Retro Commissioning
and
Energy Conservation
Report

For the

Trinity United Methodist Church and Annex

375 Broad St

Providence, Rhode Island 02907

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Provided by

Energy Engineering and Design, Inc.

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Executive Summary

In July of 2008, Energy Engineering and Design, Inc. (EE&D) was hired to Retro-Commission the mechanical systems at the Trinity United Methodist Church facility on Broad Street in Providence, Rhode Island. The intent of the Retro-Commissioning (RCx) effort is to ensure that all mechanical systems are operating efficiently in order to reduce the energy use at the facility. Additionally EE&D was asked to evaluate all other elements of the building to find any additional measures that could be implemented to save energy or improve the indoor air quality and comfort within the facility.

Background:
The Trinity Church facility comprises two attached buildings, the main church and the church annex. The main church is approximately 6,500 square feet and was constructed in 1865. The church annex is approximately 21,000 square feet and was constructed in 1940, although the mechanical systems and the basement office spaces were upgraded in 2004. The annex comprises 3 floors; the basement floor is office spaces, the main floor is church meeting rooms and a kitchen, and the top floor is a theater.

The facility is heated with gas fired hot water boilers with a hot water circulation system through perimeter radiators and two air handlers. One air handler serves the basement and one serves the theater. The heating system is controlled with approximately 36 thermostats, one for each space. The boilers are controlled with a Heat-Timer boiler controller. The total facility utility cost for 2008 was $37,442, which includes $28,335 for gas and $9,106 for electricity.

Other Reports:
In addition to this effort, there have been three other studies done for the Trinity Church; a StudioJAED report on building conditions with an energy conservation review attachment, a report from National Grid describing some potential energy conservation projects, and a report on the condition and potential improvements to the facility windows from William Murray Studios. These reports will be referenced in this report.

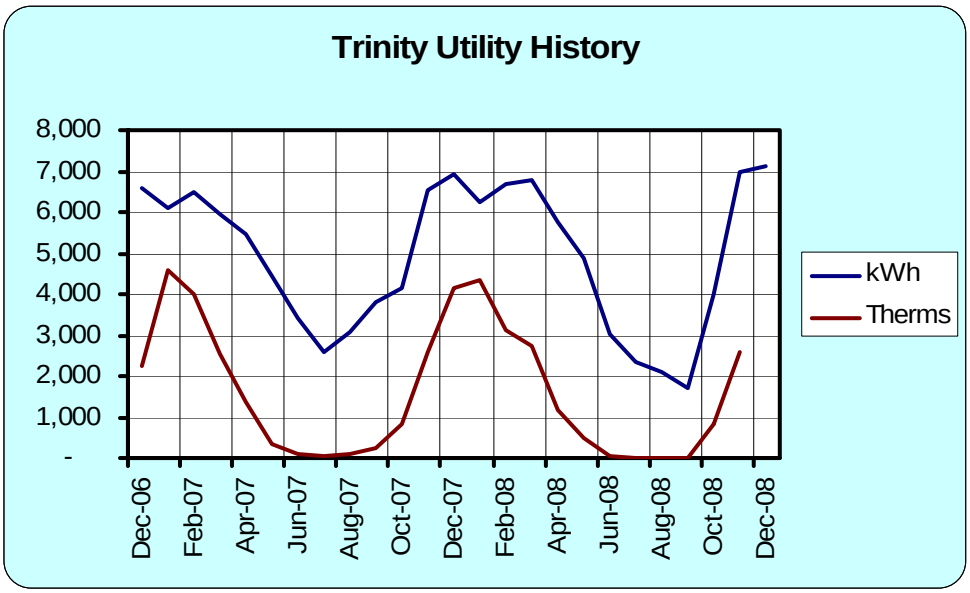
Findings:
The StudioJAED report, the NGrid report and this evaluation by EE&D, Inc. have generally agreed on the main energy conservation measures. They are:

- Reduce the infiltration of outside air through windows, doors, and other cracks and holes,
- Insulate some areas of the building,
- Install more sophisticated heating system controls (thermostats),
- Upgrade the lighting.

Utility Use Analysis

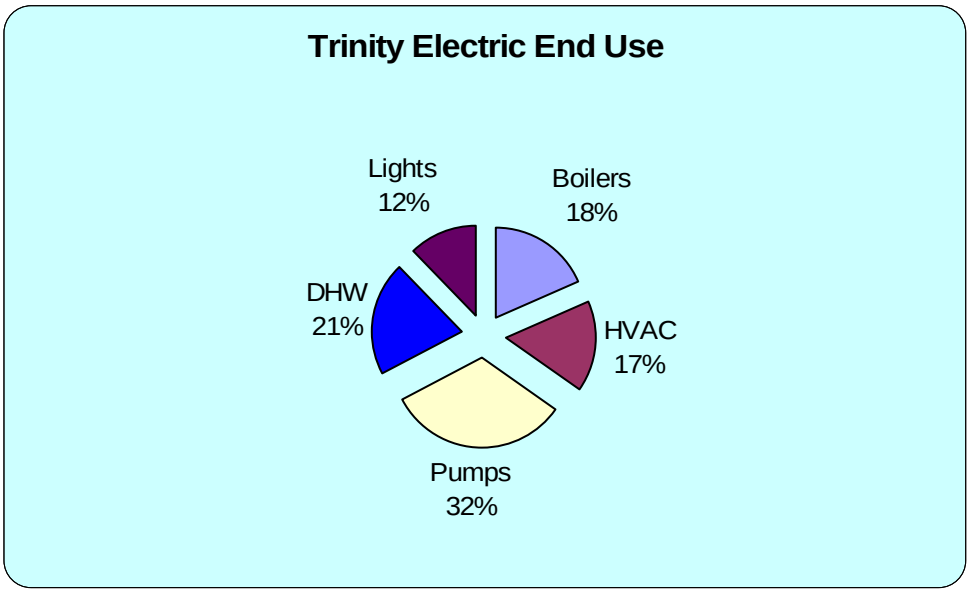
The Trinity Church and Annex buildings are provided both natural gas and electricity by National Grid. Electricity is provided under the Basic Residential Rate A-16 at an averaged annual rate of $0.1585 per kWh, and gas is provided under the C&I Medium rate at an averaged annual cost of $1.461 per therm. For the 12 month period ending in December of 2008, 19,400 therms of gas were used at a cost of $28,335 and 57,461 kWh of electricity were used at a cost of $9,106. In order to determine the Energy Use Intensity, both fuels are converted into kBtu (kBtu=1,000 Btu. Btu is a measure of heat) and divided by the building area. The Energy Use Intensity for this facility for 2008 is 74.5 kBtu/sf/year. That is somewhat more that one would expect.

The Graph below shows the history of gas and electric use at the Church and annex.



As expected, the gas use increases in the winter months for heating, but the electric use also increases significantly in the winter. The end use analysis graph on the following page shows that roughly 60% of the annual electrical use is for the heating system including; the boilers and combustion air fans 18%, the hot water pumps 32%, and the air handling units, cabinet heaters and exhaust fans 17%.

There is an electric sub-meter for the electric use in the church, and it shows that the church uses about 16% of the total electric use for the site. The gas use for the church cannot be determined directly because gas is used in the central boiler and hot water is circulated through the buildings. There is no sub-meter for this use.



Retro-Commissioning

Retro-Commissioning is the process of evaluating and adjusting building mechanical systems such that they operate as efficiently as possible to serve the building needs as they currently exist. The mechanical systems evaluated at this facility included the three modular boilers, the hot water circulation system, the Heat-Timer boiler control system, and the newly installed programmable thermostats.

The Boiler System

The heating system for the facility consists of three 1,000 kBtu Patterson Kelly Gas fired Thermific hot water boilers. They are controlled by a Heat-Timer boiler control system. The hot water system consists of three zones, one for the sanctuary, one for the theater, and one for the remainder of the annex building. Each zone has a pump to circulate the hot water. Upon review of the operation of the Heat Timer controller, EE&D Inc. found that the controller was not operating properly because it had been disabled. As a result, the boilers were cycling on and off when not needed and the temperature set points were not being met or properly controlled. EE&D reset the Heat-Timer for proper operation. EE&D Inc. recommends that the Church contract with a boiler vendor to provide regular start-up and maintenance of the boiler and control system.

The Air Handling Units

In addition to the perimeter radiation heating, there are two air handling units (AHU) in the annex building, one serves the newly renovated basement offices, and the other serves the theater. These units are each controlled by a manual on off switch mounted on the wall. When the switch is turned to the "occupied" position, the AHU turns on and operates to provide heat to the space served. The heating of the AHU is controlled by a thermostat mounted on the wall near the manual switch. These thermostats were not adjustable, but were recently replaced with programmable thermostats.

Programmable Thermostats

The old single set point thermostats were all replaced in mid-December with new programmable thermostats as a result of the recommendations of the preliminary draft of this report. Following the installation, EE&D set the occupied hours and temperature set points of all of these thermostats as needed for each area being served. In general the unoccupied set points were set to 55ºF and the occupied set points were set to 70ºF. Each thermostat was programmed with different occupied times according to the use of the space.

Energy Conservation Measures

As part of the Retro-Commissioning process, other energy conservation measures are identified. The following table provides a summary of the energy conservation measures with the associated installation cost and energy cost savings of each. Additionally, the table includes the simple payback (cost divided by savings) of each as well as the estimated utility incentive. The energy costs were calculated based on $1.50 per therm for gas.

Energy Conservation Measure Summary

ECM	Description	Estimated Cost	Annual Savings	Estimated Incentive	Net Cost	Net Payback
1	Theater Insulation	$15,000	$5,335	$10,956	$4,044	0.76
2	Theater Ceiling Hole	$2,000	$509	$1,000	$1,000	1.97
3	InnerGlass Storm Windows	$23,232	$3,969	Not Eligible	$23,232	5.85
4	Programmable Thermostats	$4,445	$2,839	$2,700	$1,745	0.61
5	Cover Vents and holes	$100	$713	$50	$50	0.70
6	Weather-strip doors[1]	$400	$6987	$200	$200	0.29
7	Tankless DHW heaters	$7,000	$1,632	Not Eligible	$7,000	4.29
	TOTALS	**$52,177**	**$15,053**	**$14,906**	**$37,271**	**2.78**

Description of the Energy Conservation Measures

ECM-1 Theater Ceiling Insulation

EE&D has evaluated adding insulation over the ceiling of the theater. Currently there is no insulation over this space, and we are proposing to add insulation up to an R-38 to comply with the latest energy codes. The two options for insulation are blown in cellulose fiber applied to the upper side of the ceiling, and 12" sprayed on icynene foam applied to the under side of the roof. Trinity should consult with an architect to determine which is the most desirable option.

ECM-2 Close Theater Roof Vent Hole

Above the ceiling of the theater, there is a ventilation hole of approximately 36" in diameter at the peak of the roof from the original construction. This hole allows hot air to escape, which cools the theater in the summer time, but it also allows heat to escape in the winter. EE&D, Inc. is proposing to close this hole and provide natural ventilation in the summer time by other means.

ECM-3: Install InnerGlass Storm Windows:

Heat loss through the old windows as well as infiltration of outside air around the window trim and seals contributes a significant amount to the heat loss of the building. As the windows are covered in detail in a study done by the William Murray Studios for the installation of stained glass, we will not include those details here. There has been much discussion about the long term solution to the stained glass window replacements at the Church.

A windows project that could be implemented in the short term to save energy is to add interior storm windows to approximately 75 windows around the annex. These windows are press fit into the existing window trim and seal tightly. They can be custom fabricated to whatever configuration is required. Some could be made as single fixed windows and some could be made a double hung windows so they could be opened.

ECM-4: Install Programmable Thermostats

The hot water heating system is controlled by a single set point thermostat at each radiator location. There are 36 of these thermostats located throughout the church and annex buildings. These thermostats are set at various temperatures and hold that temperature until they are set to another temperature by hand. This means that during the unoccupied periods as well as the occupied periods, the space is maintained at one temperature. EE&D Inc. recommends installing programmable thermostats that can be programmed to set the space temperature back to a lower temperature during unoccupied periods.

These thermostats have been installed and programmed.

ECM-5: Cover Exhaust and Vent Holes

There is an exhaust fan in the theater at one of the clerestory windows and another in the control booth that are openings to the outside where air escapes. EE&D Inc. recommends that these fan openings be retrofitted with low leakage dampers to keep air from escaping when the fan is not turned on.

ECM-6 Install Weather-Stripping on the Exterior doors

There are four wooden double doors in the facility, two in the Church and two in the Annex. These doors are old and do not seal tight and there is no weather-stripping around the doors. EE&D recommends installing weather-stripping around these four doors.

ECM-7 Install Tank-less Hot Water Heaters

Domestic hot water for the building is provided by a 50 gallon 4,500 Watt electric water heater located in the basement mechanical room. The heater holds the water at 140ºF all of the time. Hot water is not used very frequently, and when it is, the water has to run for several minutes before hot water reaches the end use at the sink.

EE&D recommends that instant hot water heaters be installed under the sink in each bathroom and in the kitchen. This will eliminate the stand-by losses of the existing hot water heater and the heat loss in all of the hot water piping. Additionally it will provide hot water instantly when the tap is turned on.

Close Church Steeple Hatch

There is a hatch in the ceiling of the stairway to the Church Mezzanine that provides access to the Church steeple. This hatch has been standing open for a long time allowing a significant amount of heated air to escape the building. EE&D, Inc., with the assistance of Trinity Restoration Inc., closed the hatch to stop the warm air from escaping. EE&D recommends that during the summer months, the hatch be opened again to allow for some natural ventilation to cool the church sanctuary.

Other Measures Considered but Not Recommended

Theater System Upgrade:

Heating for the theater space is provided by an air handler that is located above the stage area. Air from the theater space is returned to the air handler through

a grill at the ceiling of the stage and the hot air is blown into the theater through flexible ductwork to grills located at the ceiling of the theater seating area. This design causes the warm air from the air handler to circulate across the ceiling and not reach down to the floor where the theater occupants are located. In addition, the thermostat that controls the air handler is located where the occupants are. The result is that the air handler is heating all of the time and the occupants do not get warm and the thermostat does not sense any heat.

EE&D Inc. considered modifications to the HVAC ducting to improve the airflow in the Theater. The modifications included the installation of more hangers for the flexible duct in the attic and a return air duct added at the back of the stage from the ceiling to the floor so that the return air will be drawn from the floor instead of the ceiling. These design changes will draw the warm air down to and across the floor rather than just across the ceiling.

Regan HVAC Contractors provided a proposal for $8,500 to do this work. Energy savings would be minimal but comfort would be significantly improved

Digital Building Control System

Another option that was considered is the installation of a new digital energy management system for the building. This electronic system would control all of the radiators as well as the boilers, fans, pumps, and would be expandable to control any air conditioning systems or other additions to the HVAC system. A feature that might be of interest to Trinity Church is the capability of remote access so that, with the proper password, the HVAC system could be adjusted remotely by someone without the need to actually come to the church. The estimated budget cost for this alternate is $45,000.

Demand Controlled Ventilation

The two air handling units (AHU) in the annex have ductwork and dampers designed to bring in a set amount of outside air. Outside air is required by code based on the number of people in the building. The outside air dampers on the two AHU in the annex are set for a minimum of 20% outside air. This may not be enough air if the theater is full of people or the offices are fully occupied, and is certainly too much air if there is only one or two people in the space. Heating of this outside air is very costly.

EE&D Inc. considered the installing a CO_2 sensors in the return air of each AHU. These would control the amount of outside air to the minimum needed based on the CO_2 of the space which is a means of determining how many people are in the space. This will reduce the amount of outside air coming into the building.

This option is much more cost effective when added onto the installation of the Digital Control System. Given that the programmable thermostats have been installed and the HVAC systems and heating set points of the building are now

controlled, the savings would be less and the cost to provide this option alone would be much greater. This option is not cost effective at this time.

Reduce Infiltration

Another location that was identified as needing insulation and sealing of holes is in the sanctuary building, outside of the upper stained glass windows on either side of the sanctuary. There are a lot of holes in the finished ceiling and floor in this open space that allows heat to escape in the winter. In addition, there may be other locations that require insulation or sealing of cracks and holes. EE&D recommends that a specialist in this field be contacted to provide a more thorough investigation of the building and to provide a report on the work required and a proposal for the work.