



Holy Energy Conservation!

A steam boiler that runs 24/7 until somebody turns off its power is just one of the energy hogs at this comprehensive church retrofit project.

Some would classify the following story as green or combating global warming or even as saving the planet. I would simply call it a common-sense approach to energy conservation while designing an HVAC system's replacement to take advantage of today's efficient and reliable equipment. This one garners no Federal tax credit because it involves a church. Come along for a trip through this process — from inception to delivery — and I'll share with you the process I use and some fun ways to deliver the promise of comfort and economy.

The property committee at St. Paul's Church in Daltown, Pa., had been working on resolutions for their heating and cooling systems for more than three years. The newest HVAC systems had been installed in 1964 and the through-the-wall air-conditioning units in the sanctuary,

offices and lounge were noisy, inefficient, and several were no longer operational.

The 16 one-ton through-the-wall A/C units in the sanctuary incorporated a hot water coil for heating and, over time, the committee had learned to cover the exterior grills with cardboard during winter to avoid messy and costly freeze-damage from split coils. With another hot summer approaching, and several non-functioning TTW A/C units, they were feeling the heat from the congregation to finalize plans.

During their three-year journey, they had met with several mechanical contractors and knew the church needed a system-wide renovation. And that's where you and I begin our trip through this process. The property committee requested a proposal to replace their systems. During our initial visit, we'll discover the following:

A 1964 STEAM BOILER

The steam boiler, replaced in 1964, is firing at 1.8 million-Btuh. (See sidebar on timing a gas meter.) Its rating plate indicates a maximum firing rate of 1.5 million-Btuh. Over-firing = wasting energy and large production of carbon monoxide due to over-rich fuel-to-air mixture.

A wooden 2x4 frame is holding up the boiler's flue-collection box and draft diverter (fire hazard) because, as you can see, the weight of the asbestos-covered flue pipe

(large enough for Santa to slide through) has bent the heavy-gauge box where it meets the boiler's flue-gas outlet. A half-fast piece of metal hangar-strap is attached and looped over an overhead steam pipe for support, but does not work and has cut through the pipe's insulation. Death lurks here and you will point out to the property committee that no matter who gets this job, this is a situation that demands immediate attention.

The steam pressure switches are installed using iron-pipe pigtailed, which do not meet code (must be brass) and are subject to clogging with rust/mud. You are surprised to discover these two switches have been set to operate this boiler between 6- to 9-PSI. Steam systems have a specific volume within the radiators, piping and boiler, which must be filled with steam. As you increase the system pressure, steam (which is a gas) is compressed. As steam is compressed, more of it must be made in order to fill the same volume; that means burning lots more gas to do the same work of supplying heat. This was originally a vapor system designed to work on ounces, not pounds, of steam. Part of what you and I now need to do is educate the property committee about this issue that is wasting energy.



The 1964 addition uses hot water for its heating via recessed wall convectors and those 16 hybrid A/C units. Here in the boiler room, we're confronted by a large steam-to-hot-water tube-in-shell heat exchanger and a rat's nest of piping with old and tired circulators. Lots of used circulator parts lay about indicating past troubles. It's a nice application for a modulating condensing boiler if the radiation can be made to work with varying temperatures.

You're more than a bit surprised to find that this steam boiler with its haphazard flue and high pressure is set to run 24/7 until someone manually turns off the electricity to the burner! You find the motherlode of energy waste and this point will be driven home in your first report. Let's call it The Good, The Bad and The Ugly.

They've obviously had problems with unauthorized thermostat tweaking because here in the mechanical room reside all the zone thermostats wired to remote thermistors that tell these remote thermostats what the temperature is where they are located. The thermostats can be coded so that access is limited. Not bad, but they may prefer a better way with remote access via the Internet by computer or cell phone. You'll never know if you don't ask and what you're going to suggest they most likely never heard about.

So far, we've only studied the boiler room. We'll need to move on to determine what's in the rest of the church buildings that is connected to each other as one larger complex.

HOT AND COLD

In the older portions of the church, there are rooms that are hot-as-a-sweatbox and entrances on both sides of the Narthex that rapidly become cold during winter as folks come and go. We're on the outer edge of the 1-pipe steam system and the radiators are not connected across the top, meaning you cannot convert them to hot water.

The steam radiators — every one of them — have a pan or a cup placed directly under the air vents to catch condensate that's spitting up through each one. Also, there is

noticeable water damage at each radiator's valve that has stained the hardwood floors. You can offer to fix these issues by lowering the steam pressure, installing new air vents and re-packing the valve stems or replacing the valves. There are other options; you just need to ask, listen and then provide the solutions. What they told me they wanted was a total surprise. Read on.

In the attic, there are two 5-ton air handlers serving the social hall. Someone fell or stepped on the metal fiberglass-wrapped trunk line collapsing it, which is severely restricting airflow. The insulation has rebounded to conceal the damage and no one was made aware of this issue. This situation needs to be corrected.

These are relatively new A/C systems that the committee will most likely want to keep, but there's a better way to run them that will conserve energy. The filters are dirty and lots of old discarded filters litter the area. The condensate drains have dips where gunk has collected. We'll explain everything in our report.

The kindergarten room on the lower floor has the only 2-pipe steam radiators. The kitchen just off this room and adjacent to the boiler room has a stretch of commercial fin-tube baseboard as part of a hot-water zone installed upside-down near the ceiling! The old steam lines were capped off. If you or I had installed that baseboard like that, it would never have worked and we'd be back to do something a bit more conventional! A bit of creative 1964-era work.

The men's room in the lower level has a 1-pipe flat steam radiator mounted horizontally on the ceiling. The ladies room has a hot-water recessed wall convector because it's located in the 1964 addition.

As noted before, the sanctuary has 16 hybrid 1-ton A/C units with a hydronic coil for heating and the remainder of the spaces upstairs has hot-water recessed wall convectors as do all the lower floor classrooms, offices and lounge. That leaves just the three window-shaker through-the-wall units. On the day you're there, it is quite windy and air leaks past the TTW hybrid units like a sieve!

WRITING THE REPORT

After spending a day playing mechanical detective, it's time to write the report and spend some time with the property committee during their next meeting. But first, you'll need to know if that boiler is right-sized: a connected-load survey for all of the steam radiators/convectors (Burnham Heating Helper – see page 64: www.usboiler.burnham.com/PDF/htghelper.pdf); and a building heat-loss for the hydronic side.

Bear in mind that you'll be striving to explain everything you've discovered in plain English and not use the jargon that you would when talking to a fellow tradesperson. If you lose the audience at this stage, you likely won't get the work. I was stunned to find out that they no longer wanted anything to do with steam — they wanted high-efficiency boilers or a geothermal system and they were interested in mini-split inverter heat pumps to replace those 1964 rattle-trap A/C units. They're going to ask you to supply them with installation and operating costs for next month's property committee meeting. You will also be asked to provide long-term costs, life-cycle costs and payback for each system.

The total heat loss using Manual J is slightly less than 650,000-Btuh and that includes a 15% pick-up factor for the hot water piping. That means the old boiler was pumping a minimum of 1.12 million-Btuh straight up the chimney if all zones were on every time it ran. (Remember, it's on 24/7 until someone manually turns off its electricity.) But this system is divided into nine separate zones, meaning still more energy is sent to heat the Great Outdoors! How does a system get this far off course?

THE HOT-WATER SYSTEM

The tangled rat's nest of piping will be relatively easy to strip away while adding properly designed zone pumping via ECM circulators to slash parasitic energy consumption (see www.contractormag.com/features/biggest-loser-1234) while transferring comfort from source to use. The added cost will be easy to justify.

There is an easy route for venting modcon boilers and it makes sense to incorporate two that would work as a team during bitter cold weather and individually during milder weather. That will allow for a greater turndown ratio to



avoid short cycling during milder weather. A low-head-loss modcon is needed so that the primary circulator won't be a glutton for watts.

A/C AND HEATING FOR SANCTUARY, OFFICES, LOUNGE

No question those 16 rattletraps need to go. Likewise for the three TTW window-shakers. No attic space above the vaulted sanctuary ceiling and no room above the finished lower-floor classroom ceilings to conceal ductwork means new chilled/hydronic floor consoles or refrigerant-based mini-split units. Good looks as well as quiet, efficient operation are of paramount importance.

Inverter-driven mini-split heat pumps have evolved in recent years to provide good heating performance in bitter cold weather without the need for any electric-resistance elements to supplement output and floor-mounted console units would mimic the look they already were accustomed to seeing (and hearing). Eight 2-ton floor console models could replace the 16 1-ton units while occupying less space and operating so quietly that Pastor Clark could preach at a whisper if he so desired. A tri-zone set of wall-hung inverter mini-splits could serve the offices and lounge.

You'll be attending more property committee meetings to provide suggestions and, while reviewing the numerous cost factors, they will begin to narrow down the choices.

Geothermal is an early budget casualty and the property committee selects the following systems:

- Triangle Tube 399,000-Btuh Prestige Cascade System modcon boilers with control package and racking system that also functions as part of the hydronic piping. www.triangletube.com/TriangleTubeProductList.aspx?CatID=1
- Triangle Tube Smart-40 indirect water heater. www.triangletube.com/TriangleTubeProduct.aspx?CatID=6&PID=2
- Grundfos Alpha ECM zone circulators used to automatically alter flow as thermostatic radiator valves open/close. www.net.grundfos.com/doc/webnet/poweredyby/gpu/US/alpha.html
- Myson flat-panel radiant radiators in place of all steam radiators with vertical models in both Narthex entries (see note that follows regarding innovative way they are being used). www.mysoninc.com
- Ecobee thermostats so that the hydronic zones can be monitored and altered remotely. If a zone fails to respond to a call for heating (or cooling in the older side chapel-now-social-hall), an e-mail alert will be sent. www.ecobee.com

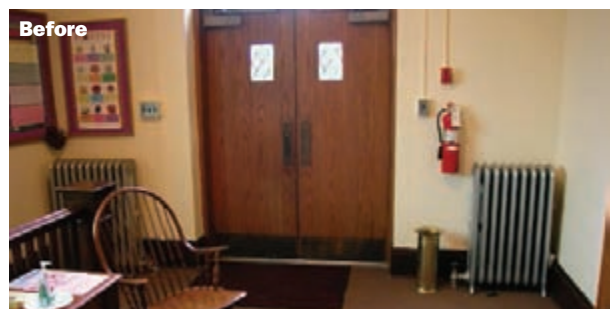


- Fujitsu inverter-driven mini-split heat pumps for the sanctuary, offices, lounge and two classrooms HVAC. One thing that's been bugging the choir: they tend to get a bit warm in their robes and would like that comfort issue resolved. The choir sits and stands adjacent to the elevated platform where the pulpit and altar are located and is just right for adding a concealed mini-split air handler. www.fujitsugeneral.com

Much as you wish that contracts are signed and you could start demolition, one major hurdle remains: give a presentation before the assembled congregation on a future Sunday morning. They will be casting the final vote! The property committee chairwoman tells you that she does not expect a favorable result and hopes you won't be too disappointed. They had been at this task for more than three years and you've invested well over 200 hours on the designs and reports. Who wouldn't be disappointed?

D-Day: They say public speaking is one of the toughest things to do. As you and your wife sit listening to the property committee chairwoman go over the proposed contract, you can audibly hear a gasp from the congregation when she reveals the cost. Not a good sign. Your knees are knocking, your heart is clamoring for a way to leap out of your chest, and you're trying to maintain a look of calm as you make your way to stand by the altar and speak. You have prepared a short presentation detailing what you discovered regarding their energy usage and a thumbnail sketch of the ultra-efficient, energy-conserving equipment is included in your proposal. The floor is opened to questions.

Storming the Beach: I'll freely confess I'd spent weeks asking myself any questions that could possibly come up after the presentation to the congregation — things I'd want



to know if I were sitting in the congregation. At first a pregnant silence, and then, a hand went up. He was not at all pleased to know how much energy that oversized boiler had been wasting. How did you determine the connected load you had just described?

A MILLION QUESTIONS

And just like the crack of a starter-pistol, the race is on with what seems like a million questions! Those new-fangled boilers — what's the heat exchanger made of — they'd better not be aluminum. I hadn't expected that curve ball. A number of congregants looked like they would judge me by that response alone, but the Triangle Tube boilers use stainless steel heat exchangers.

That led to this question (more of a comment): We hate our high-efficiency condensing boiler because of the high annual costs to keep them clean. It has to be torn apart to be serviced, which takes hours. Without hesitation, I explained that one benefit of the Triangle Tube's heat exchanger is that it is self-cleaning and will not require such a high level of maintenance. That gives me an opportunity to talk about setting them up with a maintenance contract.

Last, but not least, questions about electrical power consumption come up because of our pending deregulation in Pennsylvania. I had been hoping someone would ask that question because all of the chosen equipment is miserly where electricity consumption is concerned.

After almost one hour, the questions are all answered and, although there are some I hadn't anticipated, my homework and self-questioning enables me to quickly answer all of them.

And now the vote: The longest 10 minutes of my career elapses while ballots are handed out and collected. Only three nay votes out of more than 150 are cast!

We are ready to start this glorious undertaking and have an opportunity to socialize following the service.

Rome wasn't built in a day and if you're new to the technology, you'll want to seek out training before mak-



HOW TO CLOCK A GAS METER

If you've ever wondered just how many Btuh are being consumed by a natural gas appliance, there's an easy way to accurately determine if it's operating at its nameplate rating.

Make sure no other gas-fired appliances are running and locate the gas meter. I always use the 1-ft. dial if one is present, which makes this process and the math a bit easier.



The arithmetic is 3,600 x the test-dial-size x the Btu content for 1 cubic foot of gas in your area (the gas company will tell you the Btu content). Divide that number by the number of seconds it takes for one full revolution of the test dial.

If, for example, you are using the 1-ft. dial and gas has 1,050-Btu per cubic foot and it took 20 seconds for one revolution, it looks like this:

$$\frac{3,600 \times 1 \times 1,050}{20} = \frac{378,000}{20} = 189,000$$

ing the leap. You've got my e-mail address and I'll do my best to lend you a hand along the way if you want to get on board as an energy conservationist.

PS: I promised to reveal a trick regarding the Narthex entries. Four vertical flat panel radiators on each side greet those who enter. Backing up into that nook bathes you in delightful, soothing radiant comfort. Pastor Clark may well need a large spatula to peel away congregants — especially arthritic ones — who don't want to vacate this cocoon of comfort!

No thermostats here are wired or wireless. Just a thermostatic radiator valve and hydronic piping connected to a Grundfos Alpha Delta-P circulator that "sees" the pressure change as the thermostatic valves open and close and sends Btus in flows to match the rapidly changing conditions as folks open and close the doors. Old Man Winter creeps in only to be met by variable-speed radiant comfort. No more hot spots or cool spots, as all areas that had suffered before are now equipped with thermostatic radiator valves.

PPS: The two 5-ton A/C units serving the social hall were turned into a two-stage system by using the multi-stage feature of the Ecobee thermostat. In milder weather, only one is required, which saves energy and improves dehumidification. ♻️

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