



# “Do-It-Yourself” Faith Building Energy Audit Guide

Faith & the Common Good  
March 2018



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[Faith & the Common Good is grateful to Manitoba Hydro for their permission to copy and update the Religious Buildings Initiative: Energy Efficiency Guide for Religious Buildings document produced in 2017. We would also like to thank the Ontario Trillium Foundation, whose funding support made this guide possible.]



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# Greening Sacred Spaces: An Eco-Spirituality Project

There are thousands of religious buildings in Canada, each a valuable centre for individual and community spiritual interaction. These sacred spaces represent new possibilities in our effort to address the growing ecological crisis before us all.

When we look at these religious buildings, or any building, there is a growing appreciation that they are much more than simply structures to protect us from the natural environment. Indeed, these buildings can be seen as an integral part of our relationship with the planet, or even the entire Universe. This new and ancient cosmology moves away from a dialectical outer-versus-inner, humans-versus-nature worldview, towards a more holistic understanding of ourselves and the Universe. Rather than just protecting us from the elements, the best sacred building designs can help us interact in inspiring ways with the Creator and creation, and with one another.

Greening Sacred Spaces is about realizing our interconnected relationship with the Universe and its elements. It is a program designed to not just make our churches, gurdwaras, mosques, synagogues and temples more energy efficient and eco-friendly, but also points to ways that these sacred spaces can guide us in our everyday lives, in our homes, gardens, communities, and places of work.

From this everyday perspective, being in contact with the divine is not an abstract other-worldly relationship. Our whole world, built and organic, personal and professional, embodies the divine.

The Earth gives humanity rootedness. It 'grounds' us, feeds us, and shelters us as the walls of our sacred buildings and homes are made from its soil, wood and stone. Water is the lifeblood of every living thing, and we use it to cleanse and bless ourselves. Fire is the divine spark, and the heat and light from the sun, hearth and candle warms and brightens our lives and lifts our spirits. Air is the breath of the Creator. When imbued with incense and the scent of flowers, as it is in many sacred spaces, air literally and figuratively 'inspires' us.

These ancient sacred elements have been tapped by modern technology to offer us very practical ways of living more sustainably. The sun is captured by south-east oriented windows and photovoltaic solar panels; the air is churned by wind turbines; water flows through hydroelectric systems; the earth is tapped for its geothermal heating and cooling properties, while plants are used for 'green roofs' and 'living walls'.

All the elements can be transformed into clean energy systems, taking nothing away and creating no waste. We call this 'renewable energy' and it is one of the processes that will make it possible for humanity to reverse the negative effects wrought by old paradigm building-as-barrier thinking and instead create a truly sustainable environment that will renew ecosystems and heal planet Earth.

Join us: [www.faithcommongood.org/greening\\_sacred\\_spaces](http://www.faithcommongood.org/greening_sacred_spaces)

# Highlights

Energy audits of religious buildings show that 80 to 85 per cent of the energy used in places of worship is for heating and ventilation. Operators of religious buildings can take advantage of that finding to reduce their operating costs by making sure their heating and ventilating equipment is working as efficiently as possible, and by reducing heat loss from their facilities.

The four most cost-effective approaches to reducing heat loss are as basic as they are effective:

1. Weatherstripping and caulking around windows
2. Weatherstripping around doors
3. Insulating accessible attics and uninsulated, unfinished walls
4. Installing setback thermostats that automatically reduce heating and cooling only when areas are unoccupied.

These and other low or no-cost measures are discussed to give operators of religious buildings a range of options they can apply to reduce their energy bills while adding comfort and

attractiveness to their facility.

Roofs, walls, cladding, and other parts of the building envelope are also described in detail, to explain where to seal, how much insulation is enough, the

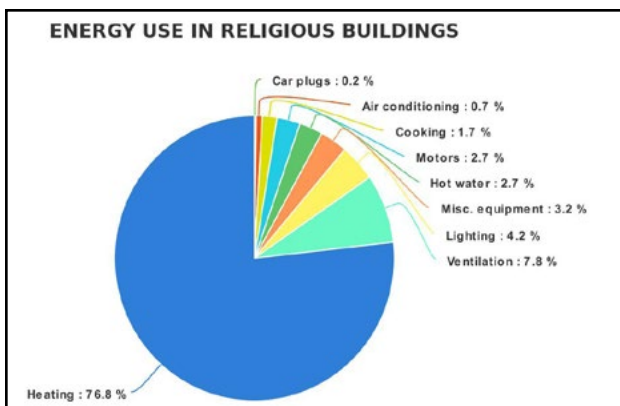
importance of vapour barriers, and the energy efficiency of various wall types, in case renovations or additions are in the works.

The section on heating systems describes electric and natural gas furnaces, steam boilers and hot water boilers, and other systems typical of religious buildings. The section includes technical details and checklists to help provide an understanding of the operation of these systems and a basis for ensuring their proper maintenance for maximum efficiency. A well-maintained heating system saves energy and money.

Heat pumps are also covered, since they are receiving considerable attention as one of the most comfortable, energy efficient, and environmentally friendly heating and cooling systems available.

The section on lighting covers energy efficient lighting that can add to the attractiveness of your facility and reap modest energy savings in cases where you keep the lights on from 35 to 40 hours a week.

To help operators identify the most practical and cost-effective measures for their facility, we have included a section on performing a simple energy evaluation. Fourteen detailed forms are provided, ready to be filled in during a “walk-through” energy evaluation. This do-it-yourself evaluation can help you identify the most practical and cost-effective measures for improving the energy efficiency of your facility. It can often make a more detailed and expensive energy audit unnecessary.



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# How to Use this Guide

This guide is intended to be used for a walk-through tour of your own faith building. Our suggested strategy is this:

1. **Make a commitment:** Orient your green team, get your board on side, then sign up: [faithcommongood.org/energy\\_benchmarking](http://faithcommongood.org/energy_benchmarking) to be able to see what impact your efforts have.
2. **Assess your performance:** Collect your energy data and benchmark your current energy use. And then either book an audit through local providers,

Faith & the Common Good (See Part 5: Energy Audits), or use this guide to do your own audit.

**DIY ENERGY AUDIT:** Gather a team of people who know the building well, or who have been involved in past efforts to upgrade it or simply keep it in working order. Have that group flip through this guide first, highlighting sections you think are relevant for you, and making an useful notes. Then use the appendices to do the actual walk through tour, filling out the pertinent information on the sheets that are relevant for you.

3. Once you've had your audit done, or done your own, it's time to use all of that information to build a plan. Contact FCG ([energy@faithcommongood.org](mailto:energy@faithcommongood.org)) if you need help.

4. **Implement your Plan:** Investigate incentives, raise funds, make upgrades, and monitor your results.

5. **Celebrate your progress** with the community! And then set new goals, and keep on going.

Contact FCG ([energy@faithcommongood.org](mailto:energy@faithcommongood.org)) if you have questions. Good luck!



# Simple Low-Cost Ways to Reduce Energy Use

Here are nearly 100 tips on improving the energy efficiency of your religious facility using low-cost or no-cost approaches. Most of them are based on the three R's: reducing operating time, reducing temperature, and reducing operating losses.

Included is a special section on water conservation, since unnecessary water use literally means pouring money down the drain.

## > 1. Reduce operating time

Usually the easiest way to reduce the operating time of any device is to turn it off when it isn't required.

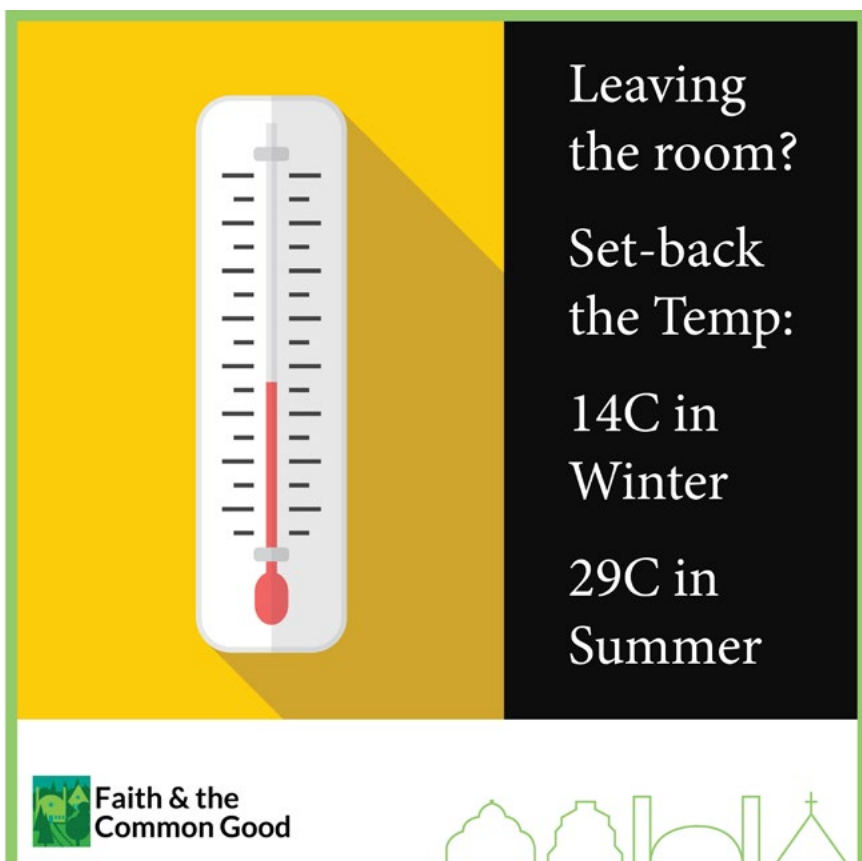
### Lights

#### Lower cost measures:

- Always turn off lights in storerooms and utility rooms when you leave the room. Put up signs advising others to do the same.
- Put up signs to encourage the last person to leave washrooms and meeting rooms to turn off the lights.
- In rooms that are seldom used but always have lights on, put up signs advising everyone to turn off the lights. Another option is to install an occupancy sensor.

#### Higher cost measures:

- Install occupancy sensors that turn the lights off when the room is unoccupied. But note that the less expensive sensors, especially the ones that replace light switches, may not be able to "see" the occupant all the time and could turn off the lights at the wrong time. Some occupancy sensors use heat and motion to sense an occupant, but these are more expensive and must be installed by an electrician.





- Turn off exterior lights during the day. Control them with a timer, a photocell switch, or a motion sensor.
- Where the lights in a room are controlled by a breaker panel, consider installing a local light switch or occupancy sensor. A less expensive alternative is to label and colour-code all circuit breakers so everyone knows which breakers control which lights.

## Natural gas pilots in summer

### Lower cost measures:

- If the furnace or boiler has a standing natural gas pilot, turn it off in the spring when the heating season ends. Natural gas pilots use as much as \$5 to \$10 worth of gas a month.
- If there is a hot water tank that is not used during the summer, turn it off and drain the tank.

These measures save money if there is someone in the congregation who is willing to turn the pilot lights off and re-light them again. If you have to call in a tradesperson to relight the pilots, it may not be worthwhile, depending on how many furnaces or boilers you have.

## Ventilation systems

### Lower cost measures:

- Ensure that washroom, gym, and kitchen exhaust fans are turned off by the last person leaving the room. Turn off general exhaust and supply fans in the late evenings or during the day when they are not required.

### Higher cost measures:

- Exhaust fans in high humidity areas, such as showers, can be controlled with a dehumidistat so they come on only to reduce the humidity, then turn off. To ensure fans are turned off when not required, connect them:
  - > In tandem with light switches
  - > To illuminated local manual switches
  - > To manual or automatic timers

- > To occupancy sensors or time clocks.

## Heating systems in summer

### Lower cost measures:

- Turn off boilers and furnaces in spring and leave them off until fall when the heating season starts.
- Turn off circulating pumps when not required.
- Turn off electric baseboards at the breaker when not required.
- Turn off unit ventilators and vestibule heaters when not required, to avoid overheating these areas.

## > 2. Reduce Operating Temperature

### Refridgerator and Freezers

#### Lower cost measures:

- The ideal temperature for refrigerators is 3°C (37°F). If the temperature is lower, turn it up.
- The ideal temperature for a freezer is -18°C (0°F). If the temperature is lower, turn it up.
- Keep freezers full. It is easier to keep a full freezer at the correct temperature than a partially empty one. Fill ice cream pails with water and keep them in a freezer that is usually less than half full.
- Keep coils at the back clean.
- Ensure refrigerators and freezers are pulled away from the wall so air can easily flow around the coils.

### Heating systems

#### Lower cost measures:

- Manually turn the thermostat back or install an automatic setback thermostat. Set back the

temperature to 14-16°C (60°F) or lower, in all areas during unoccupied hours. The set back depends on the outside temperature and how long it takes to bring the area back to normal temperature. The furnace may not be able to reheat the building in a reasonable amount of time if the temperature is set too low. If it takes a long time to reheat the building, use 16°C (60°F) and start heating earlier. Setback thermostats can save at least one per cent of the heating bill for every 1°C the temperature is lowered for an eight-hour period. Lowering the temperature from 21°C to 14°C (70°F to 60°F) overnight can save at least five per cent.

- In heating systems with circulating pumps, install a timer or thermostat to shut off circulating pumps when not required. Sometimes there are two circulating pumps that run at the same time. Normally the second pump was installed as a backup, but if a pump is not used regularly it can seize up. The easiest way to ensure that both pumps will work is to run both all the time, but this is not the most energy efficient solution as both pumps may run only partially loaded and therefore inefficiently. Only one pump should run at any time. Either switch the pumps manually on a daily basis or install a timer and a relay to operate one pump for a day and then switch to the other pump for a day. This ensures that both pumps will be available, but only one pump is being used. Both pumps may be needed on very cold days. Confirm operation with a heating expert first.
- Ensure furnace and fan filters are kept clean.
- Ensure cooling coils and any reheat coils are also kept clean. A clogged coil will reduce airflow and decrease the effectiveness of the furnace.

## Ventilation systems

The following measures, which apply to central air handling systems and air conditioners, may require professional help to ensure that you are maintaining adequate ventilation:

- Increase mixed air temperatures to reduce the volume of outside air. Mixed air temperatures are normally set at 13°C (55°F), but in some cases can be set as high as 16°C to 18°C (60°F to 65°F) without causing problems.
- Reduce discharge temperatures if there are preheat or reheat coils. This may be useful if some areas tend to get overheated. Reduce the discharge temperature to the lowest possible to keep all heated areas comfortable.

## > 3. Reduce operating losses

Making energy efficient changes to the doors, windows, and walls of a building can be expensive, particularly if you have to hire someone to do the work.

To be certain that the energy saving measures will be cost effective, conduct a detailed energy audit. A detailed audit will give you a better idea of the actual energy savings possible, and you will have a better idea whether the costs justify the expense.

### Drafts

#### Lower cost measures:

- Caulk and seal around doors and windows
  - > If you can see daylight
  - > If you can feel a draft
  - > If weather stripping is worn or missing.
- Prevent drafts from electrical outlets in exterior walls by installing foam seals and plastic plugs.

#### Higher cost measures:

- Add a second pane of glass or plastic to the inside of all single pane windows, particularly stained glass windows. Ensure the glazing is well sealed. To protect stained glass windows from vandalism, add a sheet of lexan to the outside. It is important that the lexan is not air tight, as on a location that receives direct sunlight, the air space between the lexan and stained glass may overheat and cause the lead

from the stained glass to soften. Ensure that the window is well sealed on the inside, to prevent condensation from forming as warm moist air leaks from the interior.

- Block, insulate, and seal windows that are not required for light or ventilation.

## Lights

### Lower cost measures:

- Use lower wattage lamps if a lower light level is acceptable.

### Higher cost measures:

- Install energy efficient lamps and ballasts if lamps are on for 40 hours or more per week.
- Replace regular T12 fluorescent lamps with T8 fluorescent lamps and electronic ballasts.
- Replace incandescent lamps with compact fluorescent fixtures.

Replace incandescent exit signs with LED exit signs. Power Smart incentives are often available for new LED exit signs.

## Insulation for walls and attics and heating equipment

### Lower cost measures:

- Insulate accessible attics.
- Insulate uninsulated/unfinished walls.
- Insulate basements and crawlspaces.
- Insulate hot water pipes.
- Insulate hot water tanks.
- Insulate steam and hot water heating pipes.
- Insulate condensate return tanks in steam-heating systems.
- Ensure dampers close tightly when fans are off (repair as required) or insulate and seal the dampers of unused exhaust fans.

### Higher cost measures:

- Insulate finished walls
- Replace windows

- Replace doors.

Power Smart incentives are available for insulating attics, roofs, above grade walls and upgrading windows.

## Appliances/equipment

When replacing or buying new appliances or equipment purchase units with high EnerGuide ratings or ENERGY STAR® labelling:

- refrigerators and freezers
- hot water tanks
- furnaces and boilers
- office and computer equipment
- lamp fixtures
- motors.



PHOTO: @ISTOCKPHOTO.COM/BANKSPHOTOS

## > 4. General water conservation priorities

### Leaks

- Fix leaks. Schedule regular checks of all toilets and other water-using devices. Scheduled maintenance of fixtures is usually the most cost-effective method of reducing water bills, as well as saving water heating costs.

As an added benefit, scheduled maintenance checks may reveal other problems, reducing the chance of disruptions or emergency maintenance incidents.

- A slow leak can waste about 50 000 litres of water per year. If hot water is leaking, repairing the leak will also reduce energy costs. Leaking faucets can result in stained wash basins and higher cleaning costs.
- A toilet that continues to run after flushing can waste up to 200 000 litres of water in a single year! At \$2.16 for 1,000 litres, the yearly water cost of a single toilet leak could exceed \$400.

### Fixtures

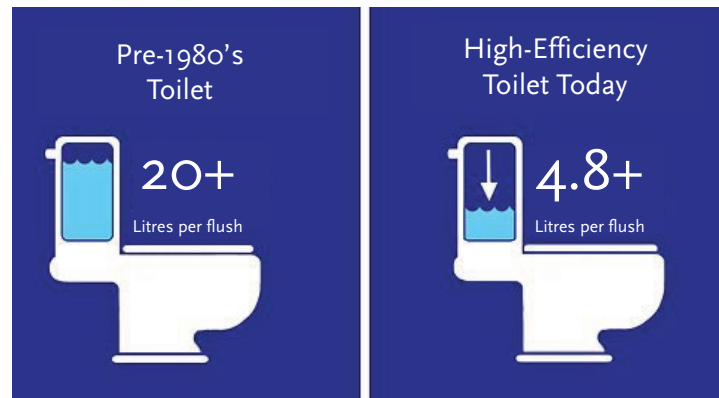
- As old fixtures need replacement, install fixtures that are cost-effective and both water- and energy-efficient.
- Retrofit existing fixtures.
- Install flow control devices on faucets.
- Install early closure devices for flappers on toilets.
- Replace existing fixtures/appliances.

### Toilets and urinals

- Reduce water use of toilets by installing toilet retrofit devices. You may want to experiment with various devices, such as early closure

devices for flappers. Payback often occurs within one year.

- Target toilets in high traffic areas for replacement with Ultra Low Flow toilets (six litres per flush).
- Fix toilet leaks. To check for a toilet leak, put a non-toxic and non-staining dye in the toilet tank. Wait fifteen minutes. If the dye seeps into the toilet bowl (no flushing), you have a toilet leak. The most common cause is a flapper that needs to be replaced.
- Determine flow rate of toilets in litres per flush. If toilet was made before 1985, it uses more than 13 litres per flush; significantly older toilets can use 20, 25, or more litres per flush. Modern low-flow toilets use six litres per flush, with ultra-low flush toilets using between 4.3 and 3 litres per flush.



### Faucets

- Bathroom faucets are normally set to eight litres per minute. Flow control devices (aerators) can reduce this to less than 3.5 litres per minute (less than 2 gallons per minute). Flow control devices should be installed on faucets with excessively high flows to reduce splashing, water waste, and hot water energy costs. However, taps in the janitor's rooms or in the kitchen for filling pots or pre-rinsing dishes should default at full flow and have a low flow option.

Note: Low flow aerators may not fit on all faucets.

- When replacing faucets, consider newer technologies. Options that should be considered: metering faucets that deliver a measured quantity of water, self-closing faucets that close as soon as the user releases the knob, and automatic sensor-controlled faucets.

Some faucets are manufactured to limit the maximum flow rate without using an aerator.

When considering payback for reducing water flow at faucets and showers, water-heating costs may add substantially to predicted savings.

## > How to determine the flow rate of faucets and showers

1. Make a measuring pail. Use a 0.25-litre (1-cup) measure to fill a 4-litre ice cream pail.
2. Mark the water level with a waterproof felt pen every 500 ml (1/2 litre).
3. Run the faucet or shower at reasonable rate. Fill the pail for 10 seconds.
4. Estimate, using the pen markings, how much water filled the pail during that time.
5. Multiply the number of litres from Step 4 by six to calculate the flow rate in litres per minute.



CONSERVATION LANDSCAPING IN ANNAPOLIS, MD

## > 5. Landscaping

- Reduce or eliminate lawns that are not used.
- Substitute junipers or other ground cover plants that require minimal water and maintenance once established.
- Use a 3-inch to 4-inch layer of mulch to cover bare soil around groundcovers, trees, and shrubs to reduce weeds and evaporation. Common mulch materials are wood chips, straw, plastic, peat moss, dried grass clippings, and bark.
- Use rain barrels with childproof lids to catch water for landscaping needs.
- Mow regularly, but leave grass 2 1/2 inches to three inches high.
- Do not over-fertilize or over-prune.
- Monitor for and fix leaks and broken sprinkler heads.
- Ensure your irrigation system is efficient. Rates of water flow should be appropriate for each area.
- Control the application of water with moisture sensors or timers.
- If possible, irrigate in the early morning to reduce evaporation caused by heat and wind.
- Consider the use of a drip irrigation system rather than sprinklers.
- Be sure hoses have shut-off nozzles.
- Higher Cost: Join the Depave Paradise network ([www.depaveparadise.ca/](http://www.depaveparadise.ca/)) to learn more about removing unwanted pavement. By removing pavement and replacing it with native plants, trees and shrubs, your faith community can increase the infiltration rate, recharging our groundwater supply, and cooling our neighbourhoods.

# Building Envelope

**Uncontrolled air leakage through the building envelope is typically responsible for up to a third, or even more, of the total heat loss of smaller buildings**

Energy needed to heat and cool buildings depends on two major factors. The first is the building envelope – roof, walls, windows and doors, and floor of the building.

The second is the building's mechanical and electrical equipment which provides the proper indoor environment. This section explains how the building envelope affects energy consumption.

The building envelope is what separates you from the wind and the weather outside. Each part of the building envelope has at least four basic systems.

These are the systems that can be improved to reduce energy consumption.

The four basic systems are as follows:

- air barrier
- insulation
- cladding and the waterproofing for roofs
- vapour barrier.

In many religious buildings it can be difficult or expensive to make improvements to the air barrier or insulation particularly if you have to remove the interior finish or open an exterior wall to do it. But if you have a bare concrete or poorly-insulated concrete block wall, adding insulation and a new interior finish can be cost effective and reduce energy consumption.

You should deal mainly with the first three systems to reduce energy consumption, although you will probably find it is easy to incorporate a vapour barrier, as we point out later in this section.

It is especially important to control air leakage because it affects the performance of the building in many different ways. For example, if you install extra insulation without first stopping all air leaks, you will probably start or increase a problem of moisture accumulation in the walls and ceiling.

Adding insulation to a poorly insulated attic is usually cost effective, but adding insulation to a flat roof should be considered only when it is time to replace or rebuild the roof.

## > Air barrier systems

Uncontrolled air leakage through the building envelope is typically responsible for up to a third, or even more, of the total heat loss of smaller buildings such as detached houses.

Air leakage out of the building is called exfiltration and air leakage into the building is called infiltration, but the common term to describe both is simply air leakage. Air leakage can affect moisture accumulation in the walls and ceiling, and temperature control inside the building, as well as energy consumption.

Your building has an air barrier system to reduce uncontrolled air leakage. Because heat loss due to air leakage is a high percentage of your energy dollars, you should retrofit and maintain what you can of your air barrier system before tackling anything else.

## Materials to use

Strictly speaking, an “air barrier” is not something you can buy from a store and apply to a building. You have to build up an air barrier system during the construction or renovation of a building.

Many different materials in a building can be converted to become part of the air barrier system, as long as the materials are reasonably impermeable to air leakage, such as drywall, plywood, concrete, and many common construction materials,

Leaks can be sealed with tape, caulking, or gaskets, as for instance, gaskets around electrical switches and outlets. You can now buy many different types of caulking which are suitable for a variety of purposes and types of building materials. Remember to ask if the caulking will set up like rubber or a compressible gasket. You don't want to have the caulking still “liquid” when it is supposed to stay in place for a long time.

Materials like acoustic sealants are NOT good for this purpose because they don't set up and are very messy. Materials like mono, silicones, polysulphide, and urethanes are better suited. For large holes and gaps, consider using a plasticene-like electrical putty compound called “duct seal” available from electrical wholesalers.

Another question that should be asked is how well the caulking stands up to cold and moisture. Do not use caulking that will quickly become brittle and crack or shrink, as it will lose its effectiveness. Make sure to use non-toxic sealants in sensitive areas such as kitchens.

## Where to seal

Leaks occur at joints between components, cracks in materials, and openings such as those for electrical boxes.

When you find an air leak in a wall or ceiling you will probably find there are several layers of construction.

At best only one of them will be damaged. This is the layer where you will have to seal the leak. If you seal the wrong layer of construction you won't stop air leakage but only direct it through some other crack or opening.

For example, if you find a leak at an electrical box in a building that was sealed using polyethylene, it may not do you any good to seal the drywall. Air will still leak through the poly and past another crack through the drywall, at the floor for instance. For some penetrations, the fixture penetrating the wall or ceiling may move in relation to the wall, creating an opening through which air can leak.

To fix a leak, the first thing to do is to figure out where the leak is best sealed. What else makes up the air barrier? What should you use to build up the air barrier?

Leakage through a building is affected by the wind and can also be caused by the stack effect. In the stack effect, air is drawn into the bottom half of a building through leaks in the structure to replace air leaving through the upper half. Unlike leaks caused by the wind, the stack effect causes slow, steady leaks.

It may be possible to convert the building's interior finish to an air barrier, which can easily be caulked and repaired. Pay special attention to the details of the building, such as corners and joints with the ceiling and floor or partitions, to make sure there are no leaks.

No matter what type of air barrier system you use, consider the following four important points before you start. The air barrier:

- Should be continuous throughout the whole building
- Must be fastened to the structure so that it can resist high wind loads. Deflection of the poly between the studs must be kept to a minimum to avoid tearing
- Should be in contact with, or sandwiched between, solid materials on both faces to prevent movement and possible tearing. Being located between drywall or sheathings and

insulating batts or sheets may not supply adequate protection and support

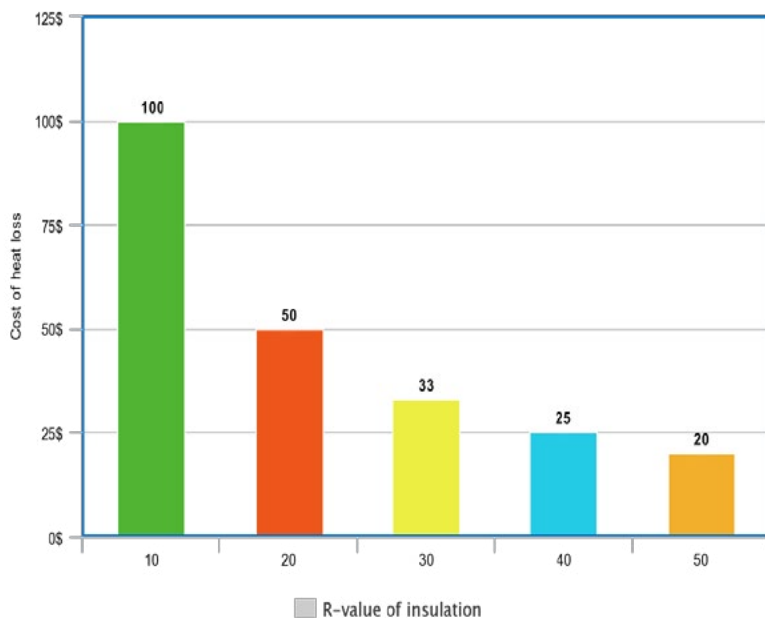
- Should have roughly the same life expectancy as the building.

## Mistakes to avoid

In recent years, people have focused on “sealing the vapour barrier” when they really meant “stopping all air leaks.”

This has worked for many cases, particularly wood frame buildings, but there are many situations where the vapour barrier has not remained sealed. The vapour barrier (or to give it its proper name, the vapour retarder), may not be the best material to seal. It may not be strong enough to remain sealed after storm winds, or it may not be possible to seal it around structural braces or metal ties in metal buildings.

Polyethylene, a common vapour barrier, can be used in wood frame buildings where it can be stapled and held between the interior wall board and the insulation and studs. For other types of construction, it is best to use materials such as wallboard, plywood, metal liner panels, or reinforced membranes to serve as your vapour barrier.



AN EXAMPLE OF THE ECONOMICS OF ADDING MORE INSULATION

## Insulation

Insulation is installed to control “heat conduction” through the building envelope. It is rated according to its resistance to conduction. This is commonly called its R-value (RSI in metric units).

If two different types of insulation have the same R-value, they will control heat conduction to the same extent. There may be differences in the requirements for installation or protection. One type of insulation may be more susceptible to moisture or some other hazard. But there will be no difference in thermal performance if each is installed and protected according to the manufacturer’s instructions.

Other factors such as durability and cost should be used to determine preferences for insulation purchases.

## How much is enough?

The higher the R-value, the lower the heat loss. This has important implications when determining how much insulation is sufficient in a building.

Suppose a wall has been built with an insulation level of R-10 (see chart). You can reduce heat loss by 50 per cent by adding an additional R-10, for a total of R-20. Upgrading the insulation from R-20 to R-30 reduces heat loss by another 16.7 per cent; from R-30 to R-40 by another 8.3 per cent and from R-40 to R-50 by another five per cent. Each addition of insulation costs the same (disregarding the extra space that would likely be required to accommodate the additional insulation) but clearly the value of each addition is not the same. Some judgment or calculation has to be made to get the most economic level of insulation.



## Installation

Insulation must be held in place in walls and ceilings so that it is not blown out by the wind or shifted if the polyethylene billows.

If you are using fibreglass or other types of batt insulation, be careful not to compress the batts too much. If this happens, you allow air to circulate in the wall or ceiling cavity and short-circuit the insulation.

All types of insulation must be carefully cut and closely fitted around protrusions, like electrical boxes or structural supports. Insulation should always be placed tight against the air barrier system, as outlined in the previous section.

Caution must be made when insulating thermally massive buildings such as stone and large brick, as the heat loss from the building keeps the mortars warm and prevents failure of the wall system. By insulating, these walls can become cold and fail. Discuss plans with a structural engineer and heritage professional.

## > Cladding

The cladding of the building protects interior elements from weathering and exposure to sun and rain. Normally this requires protection against wind gusts, sometimes with a type of building paper.

The cladding itself need not be sealed. In fact, it is best to leave it unsealed so that any water or moisture trapped inside the wall can be drained or vented to the exterior. This is exactly what happens with hardboard, vinyl, or metal siding. Some cladding systems, like brick or stucco, have weep holes purposely drilled through the exterior to allow moisture to drain. These must not be sealed.



INSTALLING INSULATION. PHOTO CREDIT: NICK NGUYEN, CREATIVE COMMONS

## > Roofing

Many roofing systems actually shed water, while some can be described technically as waterproofing. Whatever the system, water should always be directed down and away from the building.

Shingles are typically used on pitched roofs and membrane systems are commonly used on flat roofs, but strictly speaking, you should not allow a roof to be built totally flat. The more slope, the less chance there is for ponding of water on the roof which can eventually lead to leaks and further damage.

Membrane systems installed in the conventional manner for flat roofs, over the top of the insulation, are subject to deterioration due to traffic, extremes of temperature, and solar radiation.

If you have a membrane system, generally referred to as a built-up roof or BUR, and must use the roof to reach equipment that needs maintenance, consider built up walkways. However, BURs are fairly easy to repair.

A more recent innovation is the inverted roof system, which places the roof membrane under the insulation. Many insulation companies and roofing suppliers can provide one of these systems. A ballast of gravel or paving stones is often used to hold the insulation in place. Some roofing products have a concrete layer bonded to the top of the insulation to hold it in place.

## > Vapour barriers

Vapour barriers, or vapour retarders as they are correctly called, are sometimes thought to be the only defense against air leaks. This is because polyethylene is often used in housing to provide air tightness, but it is not true that poly is the only defense or even the best defense against air leaks. However, a vapour barrier is still needed on the warm side of the insulation. This can be poly or even two or three coats of an oil-based paint (not latex).

Note that if the building uses drywall, plywood, or some other system to stop all air leakage, vapour moves by diffusion directly through the material. In contrast, air moves through any opening, and will carry moisture with it, so it is very important that an air barrier be well sealed and taped.

If buildings have an enemy, it can be defined in one word: Moisture.

## > Moisture problems

If buildings have an enemy, it can be defined in one word: moisture. Moisture affects the thermal performance of the building envelope by reducing the resistance of insulation. Only a small amount of moisture in the insulation cuts the R-value by far more than anyone thought just a few years ago. This costs extra heating and cooling dollars. Moisture problems are often very difficult to discover in the first place, and may be even harder to track down and stop.

### Deterioration

Moisture that accumulates in the building envelope can lead to a variety of performance problems not directly related to energy consumption but more serious. This is especially true if the moisture attacks the building's structural integrity, such as when it rots structural members. Moisture corrodes and rusts metal components in the wall. This may become an unsightly nuisance or lead to failure of some part of the structure.

Frost and ice can also accumulate in spaces within the walls and ceiling of a building. Ice buildups can cause deformation and deterioration of interior and exterior finishes. Icicles hanging from the outside of the building may be a hazard to occupants below. When the ice and frost melt in spring, some of the melt-water may run back inside the building where it is a nuisance and further hazard.

Masonry and brick buildings can suffer additional problems with moisture. Efflorescence is the white marking that often appears on these buildings. Caused by salt that makes up part of the bricks, it is deposited on the surface by moisture. Surface staining by other materials may also occur. Moisture can cause cracking of the walls in brick and masonry buildings, and also in stucco and wood veneer buildings.

### How moisture accumulates in buildings

Moisture can get into the materials and assemblies of the building from the outside and from the inside. Outside is rain or snow and inside is humidity which can condense in the walls and ceiling spaces. Moisture condensation occurs due to air leakage, for the most part, but also due to vapour diffusion, which is handled by the vapour barrier.

Contrary to popular opinion, it is not absolutely necessary to seal the vapour barrier, because this will allow an increased amount of diffusion (a slow process) only over a small area. It is far more important to control air leakage, which may or may not be possible with the vapour barrier.

### Handling moisture

The most effective strategy is to prevent moisture from accumulating in the first place. However, almost all buildings have some form of moisture deposition or accumulation, and it is impossible to achieve a 100 per cent perfect building.



PHOTO CREDIT: SABEEL AHAMMED, CREATIVE COMMONS

A number of approaches are used to minimize condensation in buildings. In retrofit situations these basically involve reducing the amount of airflow through cracks and openings, reducing the humidity level of indoor air, or warming condensation surfaces to reduce or eliminate the condensation.

To reduce indoor humidity levels, try using ventilation fans to exhaust moist air from the building and bring in cold dry air. Heat recovery could be part of the ventilation to reduce energy costs. Another strategy is passive ventilation using the wind to induce air flow through ducts and planned openings, or increasing natural ventilation through a chimney by increasing its size. Controlling moisture also helps prevent deterioration of the building.

## > Wall types

The most common wall designs for new construction or renovations and additions fall into one of the following categories:

- wood or metal studs with drywall or plywood
- precast concrete or sandwich panels
- metal buildings
- masonry walls with reinforced membranes.

Such walls range from the expensive and durable to the inexpensive and temporary. They include the four systems discussed at the beginning of

this section – an air barrier system, insulation, cladding, and a vapour barrier.

Many of the problems associated with these designs happen at joints with other assemblies and at intersections with floors and ceilings.

## Studs and drywall or plywood

Drywall is one of the most common materials in construction, both for finish materials and as part of the air barrier system.

Isolate any openings, such as electrical outlets, to prevent air leakage at these points. Use rigid, airtight enclosures around electrical outlets, or eliminate penetration through the drywall or plywood by moving all services to interior partitions.

With metal studs, thermal bridges can develop between the interior and exterior faces of the wall because of the low thermal resistance of the studs. Consider using exterior rigid insulation to keep the cold side of the studs warm. In such an arrangement, plywood is often sealed to the outside of the studs, and rigid insulation placed on the exterior of the plywood. That leaves the stud space free for use as a service race for plumbing and electrical. Ensure good durable construction and inspect the plywood joints before the stud system is enclosed, to make sure there are no air leaks.



## Heritage Buildings

Heritage buildings require extra attention to details and construction practices when attempting energy efficiency upgrades. Many construction details used in the past are no longer used and by modifying some building envelopes, it is possible to change how the building performs, as well as how it can potentially fail. It is important when doing such work that those involved are fluent in the construction type of your building, and understand the ramifications of modifying the system. It is recommended to have a structural engineer who is fluent in heritage construction and/or a heritage professional involved in the process. The Canadian Association of Heritage Professionals is a great place to start.

## Masonry – reinforced membranes

Designs using masonry must accommodate the large amount of air leakage through such systems, and the tendency of block and brick systems to expand or contract. Concrete block will shrink initially as the material dries out, and clay-fired brick will expand slightly as the brick absorbs moisture.

Some of the newest techniques for sealing masonry or other infill panels use reinforced bituminous membranes. The membranes are usually applied as sheet materials, with a thick piece of reinforcing fabric between two layers of bitumen. The arrangement combines air impermeability and the ability to bridge gaps with increased strength and the capacity to handle movement. Similar membranes have been in use on roofing for many years.

The concrete block walls of masonry buildings are sometimes filled with insulation by pouring styrofoam beads, for example, into the core of the blocks from the top of the wall. Mortar used between the blocks can sometimes interfere with the free flow of the insulation, leaving some sections of the wall uninsulated, particularly toward the bottom. Such buildings often consume enormous amounts of energy, because the insulation is not continuous and because the walls tend to collect moisture that wets the insulation.

If you are retrofitting one of these buildings, consider the blocks as the structure only. You will still have to apply an air barrier system, a continuous layer of insulation on the inside or outside, and a vapour barrier. You will also have to install either an interior finish (which could act as the air barrier if it is properly sealed) or exterior cladding.

# Heating Systems

There is an unlimited variety of ways to heat buildings. The choice of systems is based on several factors. You need an energy source (electricity, natural gas, propane, or fuel oil) and a heat transfer medium (air, water, steam) that flows through a heat delivery system (pipes or ducts).

Typically, we use air or water as our heat transfer medium because both are in abundant supply. The heat arrives in the room through grilles and diffusers or convectors, unit heaters, or radiators. Heat flow is always from warm to cool. The rate is based on the temperature differences between the hot side and the cool side, and the resistance to flow created by walls, insulation, air films, and other building components.

The basic heating system takes the heat from the heat source and distributes it to the places that need it, using fans and ducts for air-based systems or pumps and pipes for water-based systems.

## > Furnaces

The furnace is a typical inexpensive heating unit. Furnaces are widely available using electricity, natural gas, propane or oil as a fuel source.

Furnaces come in various configurations to suit various applications. They are inexpensive to own, operate and maintain. Furnaces use air to distribute the heat to the rooms they serve.

## > General furnace maintenance tips

1. Clean or replace furnace filters every three months.
2. Clean heating and cooling coils regularly.
3. Clean filters and coils will help ensure the furnace operates efficiently by maintaining the optimum air flow and heat transfers.
4. Check fan belts for cleanliness and tightness on the pulley.
5. Replace belts that are cracked or worn.

Furnaces rarely have capacities in excess of 200 000 Btu/h (60 kW). Although furnaces are relatively inexpensive to operate and maintain, they suffer from the drawback that only one thermostat controls many rooms with different heating or cooling requirements. Furnaces are generally installed in mechanical or furnace rooms. Their efficiencies vary depending on type, operation, and the fuel they use.

## Electric

An electric furnace has an annual fuel utilization efficiency (AFUE) of 100 per cent. Essentially 100 per cent of the electrical energy supplied to the furnace is converted to heat in the building.

# How old is your furnace?

PHOTO CREDIT: HOMEENERGYCENTER.COM



## Signs you may need a new furnace

- Energy bills going up
- Furnace repairs: furnace incurs most breakdowns in last two years
- Thermostat not keeping you comfortable
- Strange noises

## Natural gas/propane – standard

A standard natural gas/propane furnace with a standing pilot has an annual fuel utilization efficiency (AFUE) of 55 to 65 per cent, despite a combustion efficiency of 75 to 80 per cent. This means that only 55 to 65 per cent of the energy supplied to the furnace is realized as useable heat in the building through an entire heating season. The AFUE is lower than the combustion efficiency because heated building air is constantly flowing out of the chimney through the draft hood on the furnace. The efficiency is lowered further by the standing pilot that operates generally throughout the year (even though it may not be required for the entire year). Note that standard furnaces are no longer available on the market.

## Natural gas/propane – mid-efficiency

A mid-efficiency natural gas/propane furnace has an annual fuel utilization efficiency (AFUE) rating of approximately 80 per cent.

The efficiency is improved over standard furnaces by replacing the draft hood with a small fan. Known as an induced draft fan, it runs only when the furnace is on. This eliminates the constant flow of heated building air out the chimney. The furnace also employs electronic ignition, eliminating the standing pilot.

## Natural gas/propane – high-efficiency

High efficiency condensing natural gas/propane furnaces are very popular as replacements for old, gravity vented furnaces. They extract 90 to 95 per cent of the available heat from the burned natural gas or propane. Efficiency is further enhanced over a mid-efficient furnace by utilizing a secondary heat exchanger which extracts the latent heat from the water vapour in the flue gases produced in the combustion process. The latent heat accounts for eight per cent (propane) and 10 per cent (natural gas) of the energy supplied to the furnace. The flue gases are then vented outside and the condensed water vapour is drained to a sewer.

High efficiency furnaces should not be installed in locations where the temperature may drop below the freezing point. There is a condensate trap on the furnace and the water in the trap could freeze. The furnace will not operate if the water in the trap freezes.

## Oil

Older standard oil furnaces have an annual fuel utilization efficiency (AFUE) rating of 60 to 70 per cent. This is due to warm air constantly passing through the heat exchanger. Older heat exchangers offer little resistance to air flow, allowing room air to freely exit the building

through the chimney even when the furnace is not operating.

Newer mid-efficiency oil furnaces are equipped with more efficient burners and offer more resistance to air flow when the burner is not firing. The AFUE rating of these furnaces is about 80 to 86 per cent.

High efficiency condensing oil furnaces have an AFUE rating of about 86 to 90 per cent. They are expensive and not commonly available.

## Commercial unit heaters

Commercial unit heaters, a variation on residential style furnaces, are available in standard-, mid-, and high- efficiency models. They are popular for heating large rooms with high ceilings.

A louvered diffuser on the discharge directs the air around the room. Generally, no ductwork is installed on the unit. If ductwork is to be attached, the unit heater must be certified to be installed with ductwork.

Unit heaters are economical to install and easy to relocate, but have limited applications and do not provide for ventilation. They are not allowed in some buildings and some occupancies as a result of building code regulations. Unit heaters are not allowed in assembly occupancies such as meeting rooms or community halls. They are well suited for storage areas, garages, and workshops.

## Rooftop packaged units

Rooftop units have a seasonal efficiency rating between 60 and 80 per cent. Their rating depends on the type of pilot, burner, unit location, cabinet insulation, and hours of operation.

As the name suggests, rooftop units put the equipment on the roof, freeing up valuable floor space. Rooftop equipment for general space heating is usually supplied with an air conditioning system, including ventilation.

Rooftop heaters with economizers use cool outside air instead of mechanical cooling to provide free cooling during the cooler hours of the day.

Rooftop units distribute air through ductwork, normally above the ceiling. They cost more than a furnace but provide cooling and ventilation in a single packaged unit. Installation costs are lower or the same as they are for furnaces of similar capacity.

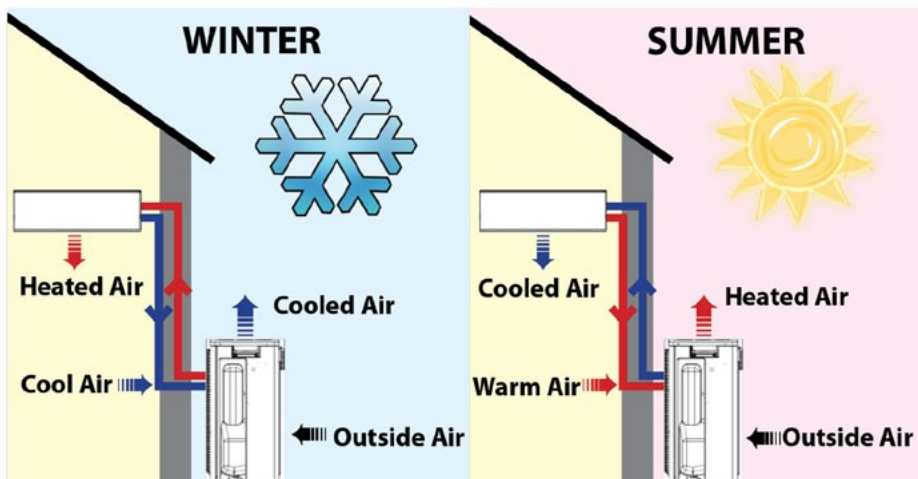
## > Heat pumps

A heat pump uses refrigerant circuits to move or “pump” heat from one location to another rather than using an electric heating element or burning fossil fuels.

Heat pump systems can be used for space heating and cooling, and water heating. An internal four-way reversing valve redirects refrigerant flow and reverses the function of the evaporator and condenser coils (a coil that absorbs heat in one case rejects heat in the reversed position), depending on whether the heat pump is in cooling or heating mode.

Ground source heat pumps have coefficient of performance (COP) ratings between 2.0 and 3.0. As a result, they can produce 2.0 to 3.0 kilowatts of heat energy for every kilowatt of electrical energy supplied to the unit. These systems have a higher first cost (installed price) but lower operating cost than conventional systems. Maintenance costs may be slightly higher than for conventional heating systems but is similar to costs for air conditioning systems.

The outdoor piping system can be either open-loop or closed-loop. An open-loop system takes advantage of the heat retained in an underground body of water. The water drawn from a well is circulated through a heat exchanger, where heat is extracted. The water is discharged back to the underground water body through a separate return or injector well. This approach is least



### > Heat Pump Basics

A heat pump is a refrigeration unit that moves heat from one place to another, much the same as a kitchen refrigerator moves heat from food inside the fridge to the coils on the back.

Unlike a refrigerator, a heat pump can be reversed, allowing heat to be moved into a facility in winter (heating mode) and out of the facility in summer (cooling mode).

PHOTO CREDIT: HEATPUMPGUYS.CA

desirable due to potential contamination of ground-water aquifers.

Closed-loop systems collect heat from the ground by means of a continuous loop of buried piping. An antifreeze solution, which has been chilled by the heat pump's refrigeration system to several degrees colder than the outside soil, circulates through the piping, absorbing heat from the surrounding soil.

For a case history on a heat pump installation for a religious building, see Appendix E.

### > Boiler systems

A boiler converts fuel energy into a form that is suitable to convey heat energy throughout a facility. In religious buildings, the most common forms of heat energy distributed from boilers are low pressure steam and hot water.

The annual fuel utilization efficiency (AFUE) rating of older natural draft fuel-fired boilers is 50 to 60 per cent—slightly lower than the 55 to 65 per cent AFUE of a furnace. The difference is because of greater heat loss from the high temperature water stored in the boiler. Newer boilers with electronic ignition and power vents or vent dampers have higher AFUE ratings of 78 to 84 per cent.

Boilers can employ baseboard radiators, convection radiators, and coils in air handlers to transfer heat to the building via convection.

Heat can also be transferred by radiation through hot water tubing installed in a concrete slab. A combination of all of these techniques can also be used.

### Steam boilers

A steam heating system uses the vapour phase of water to transport heat from a boiler to the end heating device. Steam is propelled through the supply pipe systems by the pressure generated by the boiler.

Steam boiler systems heat water to a boiling point above atmospheric pressure. The greater the pressure the higher the boiling point and the higher the heat content. When the steam reaches the point of use such as a radiator or coil, heat is removed from the steam and the steam condenses. This condensate is normally returned to the boiler to be used as boiler feed water.

Less pumping energy is required than for a hot water system, but system maintenance is high owing to the number of distribution system components such as steam traps and condensate pumps. Steam systems are more susceptible to condensate loss through steam and condensate leaks.

### Steam traps

Steam traps are installed to keep steam lines and equipment free of condensate (water), air,



and other gases. A steam trap is a valve that discharges condensate and air from a steam line or piece of equipment without discharging steam.

When starting up steam systems, lines and heating equipment are full of air which must be flushed out. During continuous operation a small amount of air and other gases, which enter the system with the boiler feed water, must also be vented.

Some steam traps have built in strainers to provide protection from dirt and scale. Unless removed, this material may cause the trap to jam in an open position, allowing the free flow of steam into the condensate collection system.

The condensate discharged from the steam trap normally flows by gravity to an atmospheric pressure return or receiver tank. In some systems the condensate may go to a flash tank first or to a drain. The condensate in the return tank is then pumped to the boiler to be used again.

The steam trap has a tight fitting valve attached to a float, inverted bucket, or bellows which rises

when enough condensate drips into the trap and fills it. When the level of condensate in the trap is high enough to operate the float, bucket or bellows, the valve opens and the pressure of the steam in the line that the trap is attached to, pushes the condensate into the condensate return line and then the valve closes sealing the steam line once more. If the valve or float/bellows operator are defective the valve will either not seal properly and steam will constantly leak into the condensate line wasting steam heat and money, or the valve will not open properly and condensate will slowly build up in the line and prevent the steam from heating the building properly, increasing the opportunity for leaks and steam or water hammer.

## Steam or water hammer

The loud banging sound you hear when a boiler system starts-up is caused by steam interacting with condensate left in the pipe due to a sag in the pipe or an improperly operating steam trap.

## > Best Management Practices for Steam and Condensate Systems

### Housekeeping

- Develop a steam trap maintenance program and procedures.
- Check and maintain proper equipment operation. Check and correct steam and condensate leaks. Train operating personnel.
- Have the condition of the pipes checked regularly by a qualified professional.
- Develop and maintain a chemical treatment program. Check control settings.
- Shut down equipment when not required.
- Shut down steam and condensate branch system

### Low cost opportunities

- Recover condensate if it presently goes to drain.
- Replace or repair leaking traps.

- Repair, replace, or add air vents.
- Insulate uninsulated flanges and fittings.
- Insulate uninsulated piping.
- Repair damaged insulation.
- Remove unused steam and condensate piping. Reduce steam pressure where possible.
- Operate equipment in an efficient operating range. Repipe system or relocate equipment to shorten pipe lengths.
- Optimize location of control sensors.

### Retrofit Opportunities

- Upgrade insulation on piping to recommended insulation thickness.
- Institute a steam trap replacement program. Optimize pipe sizes.
- Recover flash steam.
- Eliminate steam use where possible. Stage the depressurization of condensate. Recover heat from condensate.

When steam meets this little puddle of condensate, two things can happen. Either the steam causes the condensate to violently evaporate, or the steam pushes the condensate forward at speed until it meets a turn in the pipe or other restriction and gives up some of its energy as a loud noise. This noise, which sounds like a hammer hitting the pipe, is called steam or water hammer. Steam or water hammer can cause damage to steam traps and put extra pressure on joints and connectors causing leaks.

To reduce steam or water hammer, ensure there are no sags in the steam lines, the lines have the proper pitch to allow condensate to flow freely to the condensate return tank, and all steam traps are operating properly.

## Water treatment

Water for use in steam or hot water heating systems must be properly treated to avoid the problems inherent with untreated water. The two principal problems which must be overcome are scale and corrosion.

Scale is the deposit left behind by water as it is heated. Scale consists mainly of calcium and magnesium compounds. A buildup of scale on the inside of a boiler acts as a barrier to heat transfer and can reduce boiler efficiency by as much as 40 per cent with a 1/4-inch of scale.

The second problem that untreated water can cause is corrosion of the tubes in the boiler as well as in steam lines, water lines, and condensate tanks. Corrosion is primarily caused by the presence of oxygen in the water, but the acidity of the water, and the presence of carbon dioxide and dissolved solids can also increase corrosion.

## Hot water boilers

Hot water systems deliver energy from a boiler or heat exchanger to the end-use heating device by circulating water through a piping system.

In a typical system, hot water is pumped by an electric circulating pump through coils or radiators where it heats air that is drawn around the coils or radiators by natural convection or by

## > Best Management Practices for Hot Water Boilers

### Boiler operation

- Regularly check water treatment procedures.
- Maintain the total dissolved solids (TDS) of the boiler water suitably low.
- Operate at the lowest hot water temperature that still meets distribution system requirements.
- Regularly check the efficiency of boilers.
- Regularly monitor and compare performance related data.
- Regularly monitor the boiler for excess air.

### Boiler maintenance

- Boilers should receive regular maintenance—never less than once a year. Maintenance may be considered part of preventive maintenance procedures. It should include the following practices:
- Keep burners in proper adjustment.
- Check for and repair leaking flanges, valve stems, and pump glands.

- Maintain tightness of all air ducting and flue gas breeching.
- Check for “hot spots” on the boiler casing that may indicate deteriorating boiler insulation that should be repaired during annual shutdown.
- Keep the fireside surfaces of boiler tubes clean.
- Replace or repair missing or damaged insulation.
- Replace boiler observation or access doors, and repair any leaking door seals.
- Periodically calibrate measurement equipment and tune the combustion control system.

### Boiler retrofit opportunities

- Reduce boiler excess air.
- Install new boiler.
- Upgrade burner.
- Lower water temperature with an outdoor reset control

fans. The temperature of the water is determined by the output capacity of the end-use heating devices. Most heating systems require a supply temperature of 60fflC (140fflF) to 80fflC (180fflF) although some systems use water as high as 110fflC (230fflF). Water systems range from complex high temperature units to the more familiar two-pipe units found in many churches.

System efficiency is affected by four factors:

- boiler or heat exchanger efficiency
- heat loss from the piping system
- pumping energy required to maintain water flow
- water temperature.

## > Building heating system replacement requirements

For projects involving replacement of existing building heating systems, detailed and itemized load calculations should be performed by an engineer registered with the American Association of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) or by a contractor or technologist certified by the Heating, Refrigeration & Air Conditioning Institute of Canada (HRAI) or the Hydraulics Institute.

## > Recommended Specifications for Replacement Boilers and Furnaces

### 1. Natural gas fired boilers

1.1 Commercial or residential size boilers with input ratings less than 300 000 Btu/h must meet the following requirements:

- Canadian Gas Association Standard CGA P.2-1991 (Gas Fired Boilers)
- Minimum efficiency of 85 per cent (near-condensing) or 90 per cent (condensing) AFUE (Annual Fuel Utilization Efficiency) in accordance with ENERGY STAR® specifications for energy efficiency
- Electronic ignition (no standing pilot)
- Induced draft fan or power vent
- Used primarily for space heat
- Condensing boiler must be designed to withstand continuous operation with a return water temperature not exceeding 49fflC (120fflF)

1.2 Commercial boilers with input ratings of greater than or equal to 300 000 Btu/h must meet the following requirements:

- Minimum combustion efficiency of 85 per cent (near-condensing) or 90 per cent

(condensing) as per ANSI Z21.13/CSA 4.9 standards.

- Electronic ignition (no standing pilot)
- Induced draft fan OR power vent
- Used primarily for space heat
- Condensing boiler must be designed to withstand continuous operation with a return water temperature not exceeding 49fflC (120fflF)

### 2. Hot water boiler system controls

2.1 An indoor/outdoor (outdoor reset) control shall automatically adjust the supply water temperature of the system in relation to outdoor air temperature.

### 3. Natural gas furnaces

3.1 CSA approved high efficiency condensing ENERGY STAR® certified natural gas furnaces only.

3.2 Minimum efficiency of 90 per cent AFUE in accordance with ENERGY STAR® specifications for energy efficiency

3.3 Used primarily for space heat

### 4. Thermostatic controls

4.1 The supply of heating energy to each heating zone shall be individually controlled by thermostatic controls responding directly to temperature within each zone.

## > Air conditioners

Most religious buildings do not have air conditioning. Those that do have it often restrict it to the sanctuary and office areas in summer when outdoor temperatures and humidity exceed comfort levels. It can be part of a rooftop unit or built into a forced air furnace system. Window units can also provide comfort to a small area such as an office or small meeting room. Air conditioners are rated in Btu/h. They may also be rated in tons, an old-fashioned term used to describe the cooling effect felt by one ton of ice melting in a 24-hour period. One ton of cooling is 12 000 Btu/h. The efficiency of an air conditioner is expressed in two ways. One is the EER or Energy Efficiency Ratio, which is expressed as:  $EER = \text{Btu/h of cooling} / \text{watts input}$ . The second is SEER or Seasonal Energy Efficiency Ratio—essentially the EER averaged out over the entire season.

The SEER is expressed as:  $SEER = \text{Total cooling during season, in Btu's} / \text{total energy consumed, in watt-hours}$ . In shopping for an air conditioner, look for one with a SEER of 13.0 for smaller units, or an EER of 10.0 for larger units.

Large assemblies of people can generate large quantities of heat at a rate of about 130 watts/person. Very large and expensive air conditioning systems would be required to meet such peak loads. For this reason, many assembly halls may have undersized air conditioning systems.

All cooling systems rated less than 19 kW (65 000 Btu/h.) should meet or exceed ENERGY STAR® specifications and all cooling systems rated above 19 kW (65 000 Btu/h.) should meet or exceed the minimum performance standards listed in the most recent version of CSA Standards C746-06.

## > Ventilation

Whether natural or mechanical, ventilation of buildings is often required for the health and comfort of occupants.

### Natural ventilation

When an occupied room gets too hot, we like to open a window to get some fresh air into it. This is an example of natural ventilation for thermal comfort. Outside air comes into the room through the window and cools off that area. It is intentional and we are controlling it. In warm weather we are saving energy by reducing heat gain through the walls and avoiding running cooling equipment. In cold weather, opening a window increases the load on your heating system and costs money.

### Mechanical ventilation

A central mechanical ventilation system, also called a heating, ventilation, and air conditioning or HVAC system, provides a conditioned air supply through a ducted distribution system to control the interior environment of a building. A system may supply 100 per cent outdoor air with all return air exhausted, or it may operate with a portion of the return air recirculated through the system.

When a church is unoccupied, it is not necessary to supply outside air, which costs money to heat or air condition.

The Design Heating Load Calculations should be determined in accordance with generally accepted engineering standards as described in: ASHRAE Handbook and Standards, HRAI Digest, Hydronics Institute Manuals.

As a minimum, the Summary of Heating Loads (below) should be completed and signed by the registered engineer or the certified contractor or technologist responsible for the calculations and equipment sizing.

# Lighting Systems

Lighting systems in religious buildings generally account for less than five per cent of the total electricity bill. As a result, savings from installing energy efficient lighting, indoors and out, are likely to be modest.

The major benefits of upgrading your lighting are to make your facility more productive to work in and more attractive, healthier and more comfortable for the congregation.

## Incandescent

Because of its relatively poor efficiency, incandescent lighting is quickly being displaced by other types of lights. It is still used in areas where lights are to be switched often, dimmed for variable output, or in very cold temperature applications.

Life of an incandescent bulb is generally about 1000 hours, with extended service versions of up to 2500 hours. Another category called “long life” can reach operating hours of 5000 to 6000 hours. Note that longer life is achieved through the use of heavier filaments that produce less light and work less efficiently.

Colour rendition is very good. A close “relative” of incandescent lighting is quartz, which has an incandescent filament in an

envelope containing special gases. Efficiencies are 21 to 23 lumens per watt, with life ratings of up to 2000 hours. Loss of lumen output at the end of life is normally less than 10 per cent of initial values. Loss of lumen output in cold weather is less than 5 per cent.

## T8 fluorescent

T8 fluorescent lighting is extremely popular because of its efficiency, relatively good colour rendition, and very good life (15,000 to 24,000 hours). T8 fluorescents require electronic ballasts because they are a type of arc discharge lamp. Standard electronic ballasts are designed for reliable operation down to 10°F (-12.2°C); low temperature versions are available down to -18°F (-7.8°C).



PHOTO CREDIT: VIRIBRIGHT.COM

Depending on fixture construction, fluorescent lighting still remains a very economical light source. Sometimes lamp jackets or sleeves are used over the lamps to maximize light output at cool temperatures.

There is no problem with fluorescent lights during momentary power dips (such as during the starting of air conditioners or other large loads) as arc re-strike is virtually instantaneous.

Lamp output is highly dependent on temperature. Output is maximum (100 per cent) at about 25°C (77°F) and falls to about 70 per cent at -1°C (30°F). Loss of lumen output at end of life is normally about 20 per cent of the initial values.

## Metal halide – probe-start

Because of its good efficiency as well as very good colour rendition, probe start metal halide (MH) is a very popular light source. A lumen loss of about 30 per cent can be expected at the end of life of this standard technology type of MH lighting.

Some probe-start MH lamps have tended to explode at the end of their life, particularly if they were used continuously and never shut off. Rated life is about 10 000 to 20 000 hours.

There is very little lumen loss at lower temperatures [-1°C (30°F)] compared to fluorescent lamps. Probe-start metal halide lamps perform best in the base-up or base-down operating position. There is a roughly 15 per cent light loss when the lights are operated up to 30 degrees above or below horizontal. Always select a fixture with base-up burning for efficiency and ease of maintenance.

Metal halide is effectively the same lamp type as mercury vapour except that metallic additives have been added for extra efficiencies. It requires a somewhat different ballast from a mercury lamp because of higher starting voltages.

A mercury lamp operates well on a metal halide ballast, but a metal halide lamp does not operate on a mercury ballast. Warm-up and re-strike

times for metal halide lamps are slightly less than mercury.

## Metal halide – pulse-start

Pulse-start metal halide, a new technology, should be considered primarily because it is about 20 per cent more efficient than standard metal halide. In some cases, lamp life is also longer.

Pulse start is now available in a broader range of wattages between 175 and 400 watts. Lamps are ignited by a starter that emits a pulse—hence “pulse start”—rather than relying on the ballast open circuit voltage. As a result, pulse start lighting has better cold temperature starting reliabilities than standard (probe-start) MH lamps.

Because pulse start systems are becoming more popular, prices for fixtures and lamps are dropping. As a rule, the total fixture (and lamp) cost of a standard versus a pulse-start metal halide system is about equal, even though about 20 per cent fewer pulse-start fixtures are required. Installation cost is lower, and more important, less energy is required for the future life of the system. Warm-up and restart-time is faster for pulse-start technology.

Pulse-start metal halide lights have a 2-minute warm-up and a 4-minute restart time compared with probe-start metal halide lights which have a 4-minute warm-up and a 15-minute restart time.

### > Caution

For all metal halide lamp types, it is very important to change failed lamps as soon as possible after failure to avoid progressive damage to the ballast.

## High pressure sodium

High pressure sodium (HPS) lighting is quickly gaining popularity in indoor and outdoor applications because of its efficiency, low cost, and excellent lumen maintenance.

A loss of about 20 per cent of initial output can be expected at the end of its life. The light is golden or light amber and has been used for years in street and security lighting. It is quickly gaining acceptance in indoor applications where colour rendition is not critical.

A good variety of lamp wattages is available (70, 100, 150, 250, 400, and 1000 watt) as well as fixture types by many manufacturers. Ballasting for HPS sources is more critical than for mercury/metal halide sources as the ballast must have greater regulating properties as well as an electronic starting circuit to “fire” or start the lamp. Ballasts must be integrally mounted with the lamp because of the high lamp ignition voltages required.

Because HPS lamp output is relatively position insensitive, lamps can be operated in any position. HPS has excellent cold temperature operation and quicker warm-up as well as re-strike times, compared with mercury and metal halide.

Although HPS arc tubes do not rupture at end of life, a totally enclosed fixture is still recommended to protect the lamp, particularly in gymnasiums.

Normal lamps last about 24,000 hours, but dual-arc HPS lamps are available with a life of 30,000 to 40,000 hours. During a power dip or very short-term outage, the second arc of a dual-arc HPSs re-strikes immediately while the “first” arc cools down, accounting for the longer life. As with metal halide, a burned out lamp should be changed as soon as possible, as the ballast will gradually suffer damage.

It is advantageous (if possible) to match exterior as well as interior lamp wattages to simplify

stocking. A very popular lamp is the 250 watt, as well as the 400 watt.

## Low pressure sodium

Low pressure sodium (LPS) lighting is closely related to fluorescent lighting since it is a low-pressure, low intensity discharge source and has a linear lamp shape.

The lamp consists of an arc tube enclosed in a clear tubular outer bulb that has been evacuated. The colour of the light is a monochromatic yellow. It can be used in applications where colour rendition is not critical.

A large variety of wattages is available, from 18 to 180 watts. This source has the highest efficiency of all sources, ranging from 100 to 180 lumens per watt. Ballasts are required. Typical start-up times are about 12 minutes, with re-striking of the lamp immediately after interruption. This lamp type starts and performs well at temperatures below -1°C (30°F). Rated life is 18,000 hours. Wattage increases seven per cent and lumen output five per cent, by the end of lamp life.

Low pressure sodium is very good for exterior applications but has suffered market loss to HPS and MH, primarily due to system cost.

## Lighting ballasts

The average rated life of ballasts for most ballasted light sources is 15 years, and up to 20 years for premium quality ballasts.

The life of a ballast can be dramatically shortened if it is subjected to high temperatures for extended periods. Fluorescent fixtures should always be tightly surface mounted to ceilings to improve heat transfer. Suspending fixtures from ceilings results in low ballast temperatures. However, T8 electronic ballasts have very low losses and are not as temperature critical as magnetic versions.

## LED light bulbs

Light-Emitting Diodes (LED's) have been hailed as the future of lighting, as they use very little energy, claim to last a very long time (up to 50,000 hours) and, unlike CFL energy-saving bulbs, they are instantly bright when switched on. Early LEDs were limited by high prices and relatively low light output, but the technology has developed rapidly in recent years, and you can now get bright, efficient LED bulbs that replace 100W old-style bulbs and look just like a traditional bulb. What's more, prices are getting lower all the time.

LED bulbs differ from traditional incandescent bulbs in the way they produce light. While old-fashioned incandescent light bulbs passed electricity through a thin wire filament, LEDs produce light through the use of a semi-conductor that emits light energy when an electrical current is passed through it. This way of producing light is also different from regular energy-saving bulbs, which pass energy through mercury vapour to create UV light. This is then absorbed by a phosphor coating inside the lamp, causing it to glow.



PRINTABLE RESOURCE AVAILABLE ON FAITH & THE COMMON GOOD WEBSITE



# Energy Audits

An energy audit is a procedure that shows how your facility consumes energy and helps identify practical, cost-effective energy saving measures that will reduce energy use and lower operating costs.

Energy audits typically yield energy savings of 10 to 15 per cent, depending on what energy saving measures have already been applied. Almost every religious building in Canada can adopt some energy efficient measures and save energy dollars.

## > Types of audits

There are four types of energy audits. The two types described in detail in this guide are the simple walk-through evaluation and the detailed walk-through audit.

The simple walk-through evaluation, also known as a screening audit, highlights the main energy uses in the facility and points out the most obvious ways to save energy. The detailed walk-through or comprehensive audit offers an in-depth analysis of the energy use of a facility and a detailed energy saving implementation plan.

Systems evaluated in these audits include:

- the building envelope
- lighting
- domestic hot water

- heating, ventilation, and air conditioning (HVAC)
- controls.

The two other types of energy audits are the benchmark or yardstick audit, and the engineering audit.

Faith & the Common Good's Green Audit provides a general review of the energy use of a facility and the potential for energy savings. Drawing on billing data, the square footage of the building, annual weather data, and the expected energy performance values of specific building types from existing databases, it provides a performance or energy use index as well as monthly energy use and demand profiles. It indicates areas that need further study. Although a list of general energy saving ideas may be included, specific energy savings are not identified. The Green Audit also looks at air quality, food, water, waste, maintenance, landscaping, transportation, rentals, marketing and all relevant aspects to how your building works and can be improved.

The engineering audit includes detailed analyses of specific systems within a facility as well as information ranging from general recommendations to detailed engineering plans and costs.

## > Do you need an audit to save energy?

It is not always necessary to complete an energy audit to save energy, but conducting your own simple “walk-through” evaluation will help you identify energy losses that can be corrected at little or no additional costs through maintenance, operational actions, or purchasing choices.

If a more detailed technical analysis proves necessary, your initial energy evaluation will provide the important preliminary data on which to base the more detailed analysis.

## > Getting started

Whether you conduct your own simple evaluation or have a professional conduct a detailed audit for you, the first thing you will need is at least 12 months of energy information (electricity and natural gas, propane or oil). You can get this information from your utility company, your fuel supplier, or your energy bills. The information is valuable because it can tell you how much energy is used for baseload equipment such as hot water, lighting, and office equipment, and how much energy is used for heating and air conditioning.

The appendices include 14 worksheets for a “Religious Building ‘Walk-Through’ Energy Evaluation.” The sheets list questions and leave room for the answers that will serve as a record of your evaluation and the basis of applying energy saving measures.

## > Faith & the Common Good Audits

Walk-through Audits	What It Includes	Energy Star Manager	Report
<b>Green Audit</b>	A thorough review of your faith building’s energy consumption, air quality, food, operations, water usage, waste management, and landscaping practices. Its aim is to help you lower your faith building’s energy and environmental footprint, while maximizing its “mission per square foot.	Yes	Full colour PDF report highlighting the areas of concern and the opportunities at various price points to help prioritize your plans moving forward in all aspects of the building operation.
<b>Emergency Preparedness Audit</b>	A deep understanding of your energy needs and requirements during emergencies, focusing on various scenarios of emergencies and how you could engage the community.	Yes	Full colour PDF report highlighting the areas of concern and the opportunities at various price points to help prioritize your plans moving forward in all aspects of the building operation during emergencies.
<b>Regeneration Audit</b>	A broad understanding of how you can increase your faith building’s “mission per square foot” through practical suggestions meant to help you maximize its utilization by community stakeholders, based on your mission, the building’s capacity and the communities needs.	Yes	Full colour PDF report highlighting the areas of concern and the opportunities at various price points to help prioritize your plans moving forward as a thriving, engaged community member.

TRAVEL COSTS MAY APPLY TO AUDITS WHERE LOCAL AUDITING EXPERTISE IS NOT AVAILABLE.  
FOR MORE INFORMATION CONTACT FAITH & THE COMMON GOOD: [WWW.FAITHCOMMONGOOD.ORG/CONTACT\\_US](http://WWW.FAITHCOMMONGOOD.ORG/CONTACT_US)

## > Conducting your own simple walk-through evaluation

If you decide to conduct your own simple walk-through, obtain a copy of the building plans or a sketch of the layout of each floor, then walk through the facility and identify all the equipment and processes that use or cause the use of energy. Use the forms in the appendices to keep track of your findings and record your energy-saving ideas as you go.

You will need lots of time to do this properly: allow yourself at least four to five hours.

Make a list of the size and location of all energy using equipment such as motors, appliances, and lights. Include information such as operating hours and temperatures, condition of insulation and weather-stripping, locations of gaps around doors and windows.

To help you identify potential energy reduction measures, ask yourself the following questions:

- Do the lights or equipment need to stay on as long as they do?
- Can the operating temperature be reduced?

- Can more efficient equipment be installed?
- Can insulation be added?
- Can windows and doors be improved or should they be replaced?
- Can you turn it off, turn it down or tune it up?

## > Baseload calculations

Baseload calculations in a religious building are used to determine non-temperature-related loads. They provide an indication of the day-to-day use of energy.

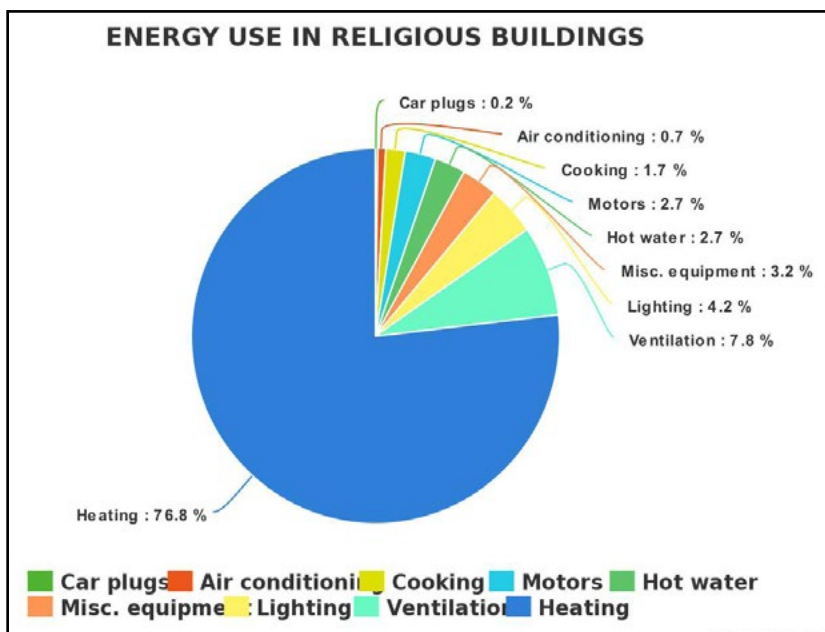
Baseload calculations in a religious building can sometimes be tricky. Religious buildings typically use natural gas, propane, or oil for heating, providing ventilation and hot water, and sometimes to operate kitchen equipment. Other equipment, such as lighting, air conditioning, office equipment, and appliances, operates on electricity.

Some churches are all-electric; others use both a fossil fuel and electricity for heating. To get a feel for how much energy is used for heating and ventilation, the easiest way is to look at the energy (fuel and electricity) that is consumed

in May and in September. In these months both heating and cooling are usually minimal but the church building is still being used regularly.

The average use for these two months can be referred to as the baseload. Any energy used above this energy level from October to April is usually heating and ventilation and anything above this amount in June, July, and August is usually cooling.

Baseload energy use consists of lighting, hot water, office equipment, and appliances. Once you have calculated how much energy is used for heating/ventilation, baseload and cooling you will have a better idea of



TYPICAL ENERGY USE IN A RELIGIOUS BUILDING.  
NOTE THAT 80 TO 85 PER CENT OF THE ENERGY USED IN A CHURCH IS FOR HEATING AND VENTILATION.

where you should put the emphasis to get the most energy savings for your efforts.

Actual energy audits show that 80 to 85 per cent of the energy used in a church is for heating and ventilation. The balance of the energy is for fans, water heating, lighting, motors, cooking equipment, and office equipment.

Some of the most cost-effective ways of reducing heating costs in a church are to caulk and weather seal around windows and doors, insulate accessible attics and uninsulated basement walls, install set-back thermostats, and turn off

ventilation systems when not required during unoccupied times or small functions.

## > Develop an energy efficiency plan

An important first step is to appoint an energy manager or an energy management committee. The role of this person or committee is to document energy savings, monitor energy bills every month, and identify potential problems that need to be looked at such as a high consumption in any one month.

It is important to involve as many people as possible in the church energy management program. Some suggestions to accomplish this are as follows:

- Post an energy chart in the foyer and update it each month.
- Consider posting one chart for electricity and one for natural gas, propane, or oil.
- Run short energy announcements or tips in the bulletin, or include an energy section in the newsletter.
- Make announcements during the service.

These are usually good ways to get everyone involved and feeling that they are helping, but to keep everyone involved will require continual new ideas and education.

## > Heating effects of electrical equipment

Electrical equipment and appliances, from lighting systems and office equipment to motors and water heaters, deliver the useful services they are designed to deliver. But the electrical energy they consume also appears as heat within the building. The heat can be useful or detrimental to the building's heating, ventilating and air conditioning systems, depending on the season.

## > Energy action plan ideas

1. If you can see daylight around the edge of doors or windows, buy the appropriate weather stripping without delay and install it and caulk around the casing to reduce drafts. The payback is almost immediate.
2. If you feel a draft around a window that does not need to be opened in the winter, consider caulking around the window using a strippable caulking (removable weatherstripping).
3. If you see a hot water or steam pipe with damaged insulation, or no insulation, buy the appropriate pipe insulation without delay and install it. The payback is almost immediate.
4. If you have incandescent lights that are on 40 hours a week or longer, convert the incandescent lamps to compact fluorescents lamps.
5. If you come across a room that has the lights on 40 hours a week or longer even though very few people use the room, consider installing an occupancy sensor.
6. If you have fluorescent lights that are on 40 hours a week or longer, convert them to T8 fluorescents lamps with electronic ballasts.
7. If you come across a room that is always heated but not always occupied, consider installing a programmable thermostat.

In cold weather, heat produced by the electrical equipment can help reduce the load on the building's heating system. In contrast, during warm weather, heat produced by electrical appliances adds to the building's air conditioning load.

Energy efficient equipment and appliances consume less energy to produce the same useful work, but they also produce less heat. As a result, efficient equipment increases the load on your heating systems in winter and reduces the load on your air conditioning systems in summer. There is a trade-off here that you need to be aware of.

The impacts of energy efficient electrical equipment and appliances on building heating and air conditioning systems are commonly called "interactive effects" or "cross effects." When considering the overall net savings of an energy efficient product, remember to factor in the interactive effects of the product on building heating and cooling systems.

Weighing the interactive effects will result in better informed decisions and realistic expectations of savings. The percentage of heat that is useful in your specific building or room will depend on several factors, including:

- location of pieces of equipment or appliances
- location of heaters and their thermostats
- type of ceiling
- size of building
- whether the room is an interior space (no outside walls or ceiling) or an exterior space (perimeter walls, with or without windows)
- the time of year (spring, summer, fall, or winter)
- type of heating, ventilation, and air conditioning system used in each room.

Unfortunately, interactive effects are often complex and may require assessment by an experienced mechanical engineer or technologist.

## > Heating effects of indoor lighting

Energy efficient indoor lighting is a good example of electrical equipment that can cause interactive effects.

Energy efficient lighting systems reduce lighting system operating and maintenance costs. In addition, they usually improve lighting quality and increase lighting levels. But lighting systems also contribute to the space heating requirements of facilities.

Electrical energy is transformed initially by a light fixture into light and two types of heating energy, then ultimately entirely into heat. The amount of electrical energy that is transformed directly into heat, infrared radiation, and visible light will be different for the various light sources commonly used (such as incandescent, fluorescent, halogen, high pressure sodium, metal halide or mercury vapour). However, the result is still the same: 100 per cent of the electricity used by the lighting system ultimately becomes heat.

For example, ten 100-watt incandescent lamps operating for 10 hours will transform 10 kWh of electrical energy entirely into heat, as follows:

- Approximately 9.7 kWh of heat will be transferred to the surroundings in two ways. First, heat will be transferred directly from the lamps by convection to the air surrounding the lamps. Second, infrared radiant energy is absorbed as heat by objects within "view" of the fixtures, and the heat absorbed is then transferred to the air by convection.
- Approximately 0.3 kWh of visible lighting energy is also absorbed by objects within view of the fixture and then transferred as heat to the air by convection.

In short, all 10 kWh of electrical energy consumed by these light fixtures will appear as heat in the building. If the same amount of light can be produced by retrofitting the fixtures to compact fluorescent fixtures that draw only 25 watts, then

in 10 hours of operation the 10 new fixtures will produce only 2.5 kWh of heat.

When the building is heated, then the heaters may have to produce a large portion of the 7.5 kWh of lost heat to maintain the same level of heating in the building. In this way, the energy you have saved by installing more efficient lighting will be offset by the additional heating required. The net energy saving may be near zero.

If the electricity you save with the new lighting is more expensive than the extra energy you need for heating, you will save with your new energy efficient lights during the heating season.

But if the electricity you save with the new lighting is less expensive than the extra energy you need for heating, your energy efficient lighting will not save as much as the additional money you have to spend on heating during the heating season.

In spring and fall, however, when neither heating nor air conditioning is needed, your net energy savings will be the same as the lighting system savings.

In summer, when the lighting system operates while air conditioning is required, an additional 33 to 40 per cent for air conditioning savings can be added to the lighting energy savings. Interactive effects do not apply to outdoor lighting.

WALL MURAL AT CALVARY CHURCH IN SIMCOE, ONTARIO. DESIGN BY: RUBBERCHICKENDESIGNS.COM



## > CASE STUDY: Lighting retrofit takes into account interactive effects

*The following scenario looks at the loss of heating caused by retrofitting a church gymnasium with energy efficient lighting.*

A gym in a church was used from September to June (43 weeks) for about 47 hours each week. It was illuminated by 45 large incandescent bulbs ranging from 300 to 500 watts.

Since the incandescent bulbs lasted only 750 to 1000 hours, and since it was a major effort to keep replacing burned-out bulbs, the church decided to look into the option of installing 45 energy efficient T8 fluorescent fixtures, each housing four lamps and equipped with electronic ballasts.

The new lamps would save electricity, shed about the same amount of light, and last 20,000 hours, virtually eliminating the difficult task of replacement.

Cost of the retrofit was estimated at \$5,000, but church officials were reluctant to go ahead without confirmation that replacing the incandescents would save money despite eliminating their higher wattages, which were acting as supplementary heating.

With assistance from their local Manitoba Hydro representative, church officials calculated the energy used by the incandescents by multiplying the wattage of each bulb by the annual hours of operation and dividing by 1000 to get kilowatthours. The same process was used to calculate the energy that would be consumed by the new T8 fluorescent lamps, assuming 120 watts for each florescent fixture and ballast.

For this evaluation it was assumed that 90 per cent of the energy used by the incandescent lights produced useful heat in the seven heating months of October to April, only 50 per cent was useful in September and May, and none was useful in June. The gym was used very little in July and August, so these months were not included in the calculations. These amounts of useful heat or



interactive effects from the incandescents during the various months were used to calculate the cost of the extra natural gas required to replace the electric heat lost with the new lighting system.

Although the new lamps would reduce electrical consumption for gym lighting by 25,466 kWh or \$1775.75 per year, it was estimated that the heating system would require an additional \$1030.50 in natural gas costs to replace the heat lost from the lights. The estimate takes into account that natural gas is cheaper than electricity, but the boiler system is only 65 per cent efficient. In summary, when interactive effects were taken into account, actual energy savings would be \$745.25 per year.

To encourage customers to replace their old non-efficient lighting systems with T8 fluorescent fixtures equipped with electronic ballasts, Manitoba Hydro offers financial incentives for replacement lamps that stay on at least 2000 hours per year. For a T8 fluorescent ballast installed in a new fixture, the incentive is \$30 per ballast for a standard ballast and \$35 per ballast for a premium ballast.

In this scenario, the incentive for replacing the 45 incandescent fixtures was \$35 times 45 or \$1,575.

The incentive lowered the \$5,000 project cost to \$3,425. With annual savings of \$745.25, the simple payback was 4.6 years.

The benefits of the retrofit were considered acceptable and the project was given permission to go ahead.

# Appendices

## **A. FORMS FOR PERFORMING A “WALK-THROUGH” ENERGY EVALUATION OF YOUR RELIGIOUS FACILITY**

1. General information
2. Electrical worksheet
3. Natural gas/propane worksheet
4. Bulk fuel worksheet
5. Lighting
6. Envelope
7. Water system
8. Heating, ventilating & air conditioning (HVAC)
9. HVAC—temperature set back
10. HVAC—controls/fans
11. Office machines & equipment
12. Appliances & equipment
13. Miscellaneous equipment
14. Landscaping

## **B. CASE STUDY: HEAT PUMPS PROVE FEASIBLE FOR CALVARY BAPTIST**

## **C. IMPROVING THE EFFICIENCY OF A HEATING SYSTEM**





FAITH & THE COMMON GOOD "GREEN AUDIT" WORKSHOP AT ST. MARK'S ANGLICAN CHURCH, BRANTFORD, ON. PHOTO CREDIT: NANCY HARVEY

## > APPENDIX A. Forms for performing a walk-through energy evaluation of your religious facility

The following forms have been developed to help you perform a walk-through energy evaluation of your religious facility .

Fill them in, in the order they are presented, to get an overview of energy consumption as a basis for identifying practical, cost-effective measures for reducing energy use and lowering operating costs .

The first step is to record general information on Form 1, then fill in the forms for all energy consumption from utility bills for the last 12 months .

Next, walk through the facility and identify all the equipment and processes that use energy or cause it to be used . Note the size of equipment, operating hours and temperatures, condition of insulation and weather-stripping, and gaps around doors and windows .

Ask yourself questions such as the following to help you identify potential energy reduction measures:

- Does the equipment need to run as long?
- Can the operating temperature be reduced?
- Can smaller more efficient equipment be installed?
- Can insulation be added?
- Can windows and doors be improved or should they be replaced?
- Can electrical equipment be operated at off-peak hours?
- CAN YOU TURN IT OFF? TURN IT DOWN? TUNE IT UP?

If a more detailed technical analysis seems necessary, then this initial energy evaluation will provide the important preliminary data needed for the detailed analysis .

Date: \_\_\_\_\_

**Religious Building  
“WALK-THROUGH” ENERGY EVALUATION FORM**

**1. GENERAL INFORMATION**

---

Facility name: \_\_\_\_\_

Mailing address: \_\_\_\_\_

Town: \_\_\_\_\_ Postal code: \_\_\_\_\_

Name of facility operator: \_\_\_\_\_

Title: \_\_\_\_\_

Phone number: \_\_\_\_\_ Fax number: \_\_\_\_\_

Name of person completing this form: \_\_\_\_\_

Title: \_\_\_\_\_

Phone number: \_\_\_\_\_ Fax number: \_\_\_\_\_

\_\_\_\_\_

Brief description of function or use of facility: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Total floor area of facility (sq. m/sq. ft.): \_\_\_\_\_

# Religious Building “WALK-THROUGH” ENERGY EVALUATION FORM

## 2. ELECTRICAL WORKSHEET

Complete one form for each electric meter in your facility. The completed form is necessary, as part of the information needed to establish your energy usage and greenhouse gas (GHG) baselines. This information will also provide you with a much better understanding of your actual energy costs.

Facility name: \_\_\_\_\_

Meter descriptor (entire facility, area, equipment, etc.): \_\_\_\_\_

Service - phase(s): \_\_\_\_\_ Voltage: \_\_\_\_\_

Utility company name: \_\_\_\_\_

Account number: \_\_\_\_\_

Hydro rate class (e.g. General Service Small – Non Demand): \_\_\_\_\_

Year: \_\_\_\_\_ No. of months: \_\_\_\_\_

Provincial tax (%): \_\_\_\_\_ GST (%): \_\_\_\_\_ City tax (%): \_\_\_\_\_

### Electrical data (A-actual E-estimated)

Month/year, or date meter read	Demand (if present on bill)		Electrical consumption (kilowatt-hours)	Total cost \$	Reading type (A, E)
	Actual (kVA)	Billed (kVA)			
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
<b>Totals</b>					

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**3. NATURAL GAS/PROPANE WORKSHEET**

*Complete one form for each natural gas or propane meter in your facility. The completed form is necessary, as part of the information needed to establish your energy usage and GHG baselines. This information will also provide you with a much better understanding of your actual energy costs.*

Facility name: \_\_\_\_\_

Units of metering – imperial (Mcf, ccf): \_\_\_\_\_ Metrics (cubic metres, or m<sup>3</sup>): \_\_\_\_\_

Utility company name: \_\_\_\_\_

Account number: \_\_\_\_\_ Rate code: \_\_\_\_\_

Fuel use (entire facility, area, equipment, etc.): \_\_\_\_\_

Year: \_\_\_\_\_ No. of months: \_\_\_\_\_

Provincial tax (%): \_\_\_\_\_ GST (%): \_\_\_\_\_ City tax (%): \_\_\_\_\_

**Natural gas / propane data**  
 (A-actual, E-estimated)

Month/year or date meter read	Natural gas / propane consumption units	Total cost \$	Reading type (A, E)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
<b>Totals</b>			

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**4. BULK FUEL WORKSHEET**

Complete one form for each bulk fuel (propane, oil, coal, wood, etc.) used in your facility. The completed form is necessary, as part of the information needed to establish your energy usage and greenhouse gas baselines. This information will also provide a better understanding of your actual energy costs.

Facility name: \_\_\_\_\_

Fuel company name: \_\_\_\_\_

Fuel type: \_\_\_\_\_ Fuel delivery units (litres, tonnes cords etc): \_\_\_\_\_

Account number: \_\_\_\_\_ Fuel cost / unit: \_\_\_\_\_

Fuel use (entire facility, area, equipment, etc.): \_\_\_\_\_

Year: \_\_\_\_\_ No. of months: \_\_\_\_\_

Provincial tax (%): \_\_\_\_\_ GST (%): \_\_\_\_\_ City tax (%): \_\_\_\_\_

**Fuel type** \_\_\_\_\_

Month/year fuel delivered	Monthly fuel consumption units _____	Total cost \$
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
<b>Totals</b>		

# Religious Building "WALK-THROUGH" ENERGY EVALUATION FORM

## 5. LIGHTING

Facility: \_\_\_\_\_

Location of lights: \_\_\_\_\_

Please use a new sheet for each area, location or room in the facility.

### Existing lights and controls

	Type 1	Type 2	Type 3	Type 4
Type of fixtures (see legend):				
Number of fixtures:				
Number of lamps per fixture:				
If fluorescent indicate length of lamps (2 ft, 3 ft, 4 ft, 8 ft):				
Watts per fixture: (Include ballast wattage if known)				
Fixture height from work surface(ft/m)				
Foot-candle level (if known) – measured at work surface – foot candles				
Present operation of lights - hours/day				
Present operation of lights - days/week				
Present operation of lights – weeks/year				
Proposed operation of lights - hours/day				
Proposed operation of lights - days/week				
Proposed operation of lights - weeks/year				

Present light levels: Bright \_\_\_\_\_ Adequate \_\_\_\_\_ Dim \_\_\_\_\_

Reflectance of walls and ceilings: Good \_\_\_\_\_ Average \_\_\_\_\_ Poor \_\_\_\_\_

Can lights be switched on and off as desired? Yes \_\_\_\_\_ No \_\_\_\_\_ Comment: \_\_\_\_\_

Can lower wattage lamps be installed? Yes \_\_\_\_\_ No \_\_\_\_\_ Comment: \_\_\_\_\_

Can existing lamps/fixtures be retrofitted? Yes \_\_\_\_\_ No \_\_\_\_\_ Comment: \_\_\_\_\_

Is there an automatic timer? Yes \_\_\_\_\_ No \_\_\_\_\_ If yes, is it set properly? Yes \_\_\_\_\_ No \_\_\_\_\_

Is there an occupancy sensor? Yes \_\_\_\_\_ No \_\_\_\_\_

If No, can an occupancy sensor be installed? Yes \_\_\_\_\_ No \_\_\_\_\_

**Energy action plan ideas:** \_\_\_\_\_

### Lighting Legend

A.- Incandescent

D.- Compact Fluorescent

G.- High Pressure Sodium

J.- Fluorescent T8

M.- Exit lamp—compact fluor.

B.- Fluorescent T-12

E.- Mercury Vapour

H.- Low Pressure Sodium

K.- Quartz Halogen

N.- Exit lamp - LED

C.- Fluorescent T-12 HO (high output)

F.- Fluorescent T-12 VHO (VH output)

I.- Metal Halide (white light)

L.- Exit lamp - incandescent

O - LED

# Religious Building "WALK-THROUGH" ENERGY EVALUATION FORM

## 6. ENVELOPE

Facility: \_\_\_\_\_ Direction wall face \_\_\_\_\_

For each wall area of facility (front, sides and back of a building) please use one sheet.

### WINDOWS (Please circle appropriate Yes or No)

Are storm windows used?	Number of glazings	Description of window type (double hung, slider, casement, etc.)	Do windows open?	Window fit (poor, fair, good)	No. of windows
Yes No			Yes No		
Yes No			Yes No		
Yes No			Yes No		

### DOORS (Please circle appropriate Yes or No, and circle units used)

Are storm doors used?	Is door Insulated?	Description of door type (overhead, insulated metal, wood, etc)	Condition of door (warped, cracked)	Door fit (poor, fair, good)	Number of doors
Yes No	Yes No				
Yes No	Yes No				
Yes No	Yes No				

Number/location of broken or cracked windows: \_\_\_\_\_

Description of door or window repairs or replacements needed (including door closers): \_\_\_\_\_

Caulking: \_\_\_\_\_ feet/metres required

Weather-stripping: \_\_\_\_\_ feet/metres required

### INSIDE (Please circle appropriate Yes or No)

Insulation location	Insulated ?	Present thickness	Insulation Types
Ceiling (attic)	Yes No		
Walls	Yes No		
Basement/crawlspace walls	Yes No		
Floor / slab	Yes No		

Location of drafts (use strip of tissue to locate): e.g., doors, windows, elec. outlets, attic hatches, cracks, etc.

Is attic ventilation installed? Yes \_\_\_\_ No \_\_\_\_ Comments \_\_\_\_\_

Energy action plan ideas: \_\_\_\_\_

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**7. WATER SYSTEM**

Facility name: \_\_\_\_\_

Please fill in one sheet for each hot water tank. Please circle units used: e.g., gallons/litres

**System components**

Type of water heater, energy (fuel) used: \_\_\_\_\_

Tank storage capacity: \_\_\_\_\_ gallons/litres      Number of tanks: \_\_\_\_\_

Recovery rate: \_\_\_\_\_ gallons/litres per hour      Size of heating element: \_\_\_\_\_

Temperature setting: \_\_\_\_\_ °C/°F

Make, model, age: \_\_\_\_\_

Tank insulation (type/thickness): if known \_\_\_\_\_

Is tank equipped with a heat trap?    Yes \_\_\_\_\_ No \_\_\_\_\_

Location, description of other heaters, if any: \_\_\_\_\_

Length of heated uninsulated distribution piping: \_\_\_\_\_ feet/metre

**Hot water temperatures**

*(Please circle units used)*

At showerhead: \_\_\_\_\_ °C/°F.    At faucet nearest tank: \_\_\_\_\_ °C/°F

At dishwasher: \_\_\_\_\_ °C/°F.    At washing machine: \_\_\_\_\_ °C/°F

At other location: ( \_\_\_\_\_ ): \_\_\_\_\_ °C/°F

Showerheads, faucets, toilets, other *(Please circle units used)*

Showerheads:    Rate of flow: \_\_\_\_\_ gallons/litres per minute.    No. of showerheads \_\_\_\_\_

Average use/day: \_\_\_\_\_ minutes per shower

Faucets:    Rate of flow: \_\_\_\_\_ gallons or litres per minute.    No. of faucets \_\_\_\_\_

Number of toilets: \_\_\_\_\_    Tank Size: \_\_\_\_\_ gallons/litres.    Times used per week: \_\_\_\_\_

Dishwasher: Capacity: \_\_\_\_\_ gallons/litres.    Times used per week: \_\_\_\_\_

Washing machine capacity: \_\_\_\_\_ gallons/litres.    Times used per week: \_\_\_\_\_

Have cool water washing machines been tried?    Yes \_\_\_\_\_ No \_\_\_\_\_    Comment: \_\_\_\_\_

**Energy action plan ideas:** \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_



**Religious Building**

**“WALK-THROUGH” ENERGY EVALUATION FORM**

**8. HEATING, VENTILATING & AIR CONDITIONING (HVAC) SYSTEMS**

Facility name: \_\_\_\_\_

*Please use another sheet if required.*

**Air conditioning**

Number of units: \_\_\_\_\_

Make, type, size, location of each: \_\_\_\_\_

Frequency of servicing: \_\_\_\_\_ Date of last servicing: \_\_\_\_\_

Has the HVAC system been “balanced”? Yes \_\_\_\_\_ No \_\_\_\_\_

**Heat pumps**

Number of units: \_\_\_\_\_

Make, type, size, location of each: \_\_\_\_\_

Do they have auxiliary heating? Yes \_\_\_\_\_ No \_\_\_\_\_

If so, do they have controls that minimize use of that heating? Yes \_\_\_\_\_ No \_\_\_\_\_

Frequency of servicing: \_\_\_\_\_ Date of last servicing: \_\_\_\_\_

**Central heating plant and system**

*(Please circle units used)*

Location: \_\_\_\_\_

Type of fuel used: \_\_\_\_\_

Type of system (e.g., hot water, steam, warm air) \_\_\_\_\_

If you have a steam system, when were the traps last checked? \_\_\_\_\_

Number of zones: \_\_\_\_\_

Age of boiler or furnace: \_\_\_\_\_ Type, condition of insulation on boiler: \_\_\_\_\_

Age of burner: \_\_\_\_\_ Is domestic hot water heated by the boiler? \_\_\_\_\_

Steam pressure \_\_\_\_\_ (PSI) Or hot water temperature \_\_\_\_\_ (°C/°F)

Type and condition of insulation on air ducts or on distribution piping: \_\_\_\_\_

Frequency of testing/cleaning adjustment: \_\_\_\_\_ Date of last test/service: \_\_\_\_\_

Results of test (e.g., combustion efficiency, in %): \_\_\_\_\_

**Energy action plan ideas:** \_\_\_\_\_



**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**10. HVAC—CONTROLS/FANS**

Facility name: \_\_\_\_\_

Please use a new sheet for each zone, area, or room in the facility.

**Controls/use** (Please circle units used)

Location(s) and description of thermostats: \_\_\_\_\_

Location of setback clock/setback thermostat: \_\_\_\_\_

Cold weather thermostat setting \_\_\_\_\_ °C/°F. Is temperature set back at night and on weekends? \_\_\_\_\_

If “Yes,” what are setback times and temperatures for nighttime? \_\_\_\_\_ weekends? \_\_\_\_\_

Is temperature setback automatic? \_\_\_\_\_ or manual? \_\_\_\_\_

Hot weather thermostat setting: \_\_\_\_\_ °C/°F. Is temperature setup at night and on weekends? \_\_\_\_\_

If “Yes,” what are setback times and temperatures for: nighttime \_\_\_\_\_ weekend \_\_\_\_\_

Is temperature setback automatic? \_\_\_\_\_ or manual? \_\_\_\_\_

How many hours a week and weeks per year is the system used?

Hours & weeks in hot weather \_\_\_\_\_ Hours & weeks in cold weather \_\_\_\_\_

When is system turned on/off in relation to daily occupancy (i.e., before, after, by how long)?

Which areas are too hot? \_\_\_\_\_

Which areas are too cold? \_\_\_\_\_

**Fans**

(Supply, return, exhaust, circulating, etc. Please circle appropriate Yes or No)

Function: (supply, return, etc.)	Area served:	Fan operating hours			Can fans be cycled to reduce operating times?	
		hours per day	days per week	weeks per year	Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No

Energy action plan ideas: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**11. OFFICE MACHINES & EQUIPMENT**

(Computers, printers, photocopiers, etc.)

Facility name: \_\_\_\_\_

*Please use more sheets if required*

**Office machine**

Machine type, location \_\_\_\_\_

Wattage (nameplate watts, or amps x volts): \_\_\_\_\_

Is it left on overnight? \_\_\_\_\_ Over weekends? \_\_\_\_\_

Daily hours of operation: \_\_\_\_\_ Hours per day it could be turned off: \_\_\_\_\_

**Office machine**

Machine type, location \_\_\_\_\_

Wattage (nameplate watts, or amps x volts): \_\_\_\_\_

Is it left on overnight? \_\_\_\_\_ Over weekends? \_\_\_\_\_

Daily hours of operation: \_\_\_\_\_ Hours per day it could be turned off: \_\_\_\_\_

**Office machine**

Machine type, location \_\_\_\_\_

Wattage (nameplate watts, or amps x volts): \_\_\_\_\_

Is it left on overnight? \_\_\_\_\_ Over weekends? \_\_\_\_\_

Daily hours of operation: \_\_\_\_\_ Hours per day it could be turned off: \_\_\_\_\_

**Office machine**

Machine type, location \_\_\_\_\_

Wattage (nameplate watts, or amps x volts): \_\_\_\_\_

Is it left on overnight? \_\_\_\_\_ Over weekends? \_\_\_\_\_

Daily hours of operation: \_\_\_\_\_ Hours per day it could be turned off: \_\_\_\_\_

**Energy action plan ideas:** \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**12. APPLIANCES AND EQUIPMENT**

Facility name: \_\_\_\_\_

*Please use another sheet if required.*

**Refrigeration and freezing** *(Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Compressor rating: \_\_\_\_\_ hp; age: \_\_\_\_\_ years  
Present temperature: °C/°F \_\_\_\_\_ Hours per day of use: \_\_\_\_\_ Weeks per year of use: \_\_\_\_\_  
Do doors close completely, by themselves? \_\_\_\_\_ Condition of door seals: \_\_\_\_\_

**Refrigeration and freezing** *(Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Compressor rating: \_\_\_\_\_ hp; age: \_\_\_\_\_ years  
Present temperature: °C/°F \_\_\_\_\_ Hours per day of use: \_\_\_\_\_ Weeks per year of use: \_\_\_\_\_  
Do doors close completely, by themselves? \_\_\_\_\_ Condition of door seals: \_\_\_\_\_

**Refrigeration and freezing** *(Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Compressor rating: \_\_\_\_\_ hp; age: \_\_\_\_\_ years  
Present temperature: °C/°F \_\_\_\_\_ Hours per day of use: \_\_\_\_\_ Weeks per year of use: \_\_\_\_\_  
Do doors close completely, by themselves? \_\_\_\_\_ Condition of door seals: \_\_\_\_\_

**Cooking** *(range, oven, grill, etc. Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Temperature now used: °C/°F \_\_\_\_\_  
Is this lowest possible temperature? Yes \_\_\_ No \_\_\_ Is equipment turned off when possible? \_\_\_\_\_  
Are exhaust hoods installed over all cooking equipment? Yes \_\_\_\_\_ No \_\_\_\_\_

**Cooking** *(Range, oven, grill, etc. Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Temperature now used: °C/°F \_\_\_\_\_  
Is this lowest possible temperature? Yes \_\_\_ No \_\_\_ Is equipment turned off when possible? \_\_\_\_\_  
Are exhaust hoods installed over all cooking equipment? Yes \_\_\_\_\_ No \_\_\_\_\_

**Cooking** *(Range, oven, grill, etc. Please circle units used)*

Type, age, energy used: \_\_\_\_\_ Temperature now used: °C/°F \_\_\_\_\_  
Is this lowest possible temperature? Yes \_\_\_ No \_\_\_ Is equipment turned off when possible? \_\_\_\_\_  
Are exhaust hoods installed over all cooking equipment? Yes \_\_\_\_\_ No \_\_\_\_\_

**Energy action plan ideas:** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**13. MISCELLANEOUS EQUIPMENT**

Facility name: \_\_\_\_\_

*Please use another sheet if required.*

**Washer/dyer** (if applicable)

Type, age, energy used: \_\_\_\_\_

Temperature now used: Hot \_\_\_\_\_ Warm \_\_\_\_\_ Cold \_\_\_\_\_

Are machines fully and properly loaded? Yes \_\_\_\_\_ No \_\_\_\_\_

Can lower washing/rinse water temperatures be used? Yes \_\_\_\_\_ No \_\_\_\_\_

**Dish washer #1** (if applicable)

Type, age, energy used: \_\_\_\_\_

Temperature now used: Hot \_\_\_\_\_ Warm \_\_\_\_\_ Cold \_\_\_\_\_

Are machines fully and properly loaded? Yes \_\_\_\_\_ No \_\_\_\_\_

Can lower washing/rinse water temperatures be used? Yes \_\_\_\_\_ No \_\_\_\_\_

**Dish washing #2** (if applicable)

Type, age, energy used: \_\_\_\_\_

Temperature now used: Hot \_\_\_\_\_ Warm \_\_\_\_\_ Cold \_\_\_\_\_

Are machines fully and properly loaded? Yes \_\_\_\_\_ No \_\_\_\_\_

Can lower washing/rinse water temperatures be used? Yes \_\_\_\_\_ No \_\_\_\_\_

**Car plugs (car, block or car & block heaters)**

*(Please circle appropriate Yes or No)*

Function: (car, block car & block)	Description of parking lot served:	Plug operating hours			Can plugs be cycled to reduce operating times?	
		hours per day	days per week	weeks per year	Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No
					Yes	No

Energy action plan ideas: \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

**Religious Building**  
**“WALK-THROUGH” ENERGY EVALUATION FORM**  
**14. LANDSCAPING**

Facility name: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

*Complete forms for “green” areas. The completed form is a necessary part of the information needed to establish how your water is being used.*

**Irrigation practices:**

Irrigated area	Length of time irrigated per week	Sprinkler flow rate	Total water use per week

**Best management practices**

- Specifically mandate the use of heat-tolerant low-water use plants.
- Limit turf areas.
- Mow regularly, but leave grass 2 1/2 inches to 3 inches high.
- Use mulch around groundcovers, trees, shrubs, etc.
- Do not over-fertilize or over-prune.
- Monitor for and fix leaks and broken sprinkler heads.
- Ensure your irrigation system is efficient (rates of water flow for each area are appropriate)
- Control application of water with moisture sensors or timers.
- If possible, irrigate in the early morning to reduce evaporation caused by heat and wind.
- Consider the use of a drip irrigation system rather than sprinklers.
- Be sure hoses have shut-off nozzles.

## > APPENDIX B. Case Study: Heat pumps prove feasible for Calvary Baptist

*The following case history was prepared to explain how an electrically heated religious facility determined that it would be feasible to install heat pumps, then followed through with the installation, which has added comfort year-round and saved on energy bills despite an addition to the sanctuary.*

*It was prepared to convey the importance of conducting a feasibility study if you consider that your religious facility could benefit from installation of a heat pump.*

When Calvary Baptist Church in Killarney increased the size of its sanctuary by 150 per cent, the heating bills remained roughly the same as before, and the church now has the added bonus of air conditioning as well.

“In 1999 we increased our 2000-square-foot sanctuary by another 3000 square feet, bringing the total to just over 5000 square feet,” says Mark Bryce, church treasurer.

“Then we tore out the old electric baseboards and installed a new heat pump system. It uses two heat pumps that are roughly the same size as a regular furnace.

“Our heating and cooling bills are now roughly \$3,400 a year, compared with about \$3,000 a year just to heat the building in the past, even though we now have over twice the area.

“In other words, with our new heat pump system, we’re getting twice the heat for about the same money, with air conditioning thrown in.”

### Packed to the rafters

The new system consists of two heat pumps, each about the size of a natural gas furnace. The heat pumps use a forced air system to keep the church warm in winter and cool in summer.

“It’s an incredibly even heating and cooling system,” says Bryce. “With all the air changes, you get a fresh-air feeling, no matter what time of year, even when the church is packed to the rafters.”

The system was installed with the help of a financial incentive under Manitoba Hydro’s Earth Power (Geothermal Heat Pump) Program.

The program offers information and financial assistance to Hydro’s commercial, industrial, and agricultural customers to install electrical energy saving measures in new construction and renovation projects.

The level of financial assistance is based on electrical savings determined in a feasibility study, which also qualifies for assistance under the program.

The feasibility study, prepared by an engineering firm, showed it would cost \$51,000 to install a heat pump system. In contrast, adding more baseboards would have cost only \$32,000.

Costs in both cases included installing duct work for a forced air system to handle air conditioning, which the church wanted. Heating and cooling the enlarged sanctuary would cost only \$2000 a year with a heat pump system, but \$5,000 a year with baseboards and a conventional air conditioner.

### Payback drops

As a result, the heat pump system would normally have paid for itself in 6.3 years. With the help of Manitoba Hydro’s Earth Power (Geothermal Heat Pump) Program, the payback dropped to three years.

The heat pump system is complemented by energy efficient windows and an air barrier system – both of which are covered under the Commercial Building Envelope Program.

New windows in the church feature triple glazing and high-density insulating spacer bars to improve energy performance and reduce condensation.

An air barrier system was also built into the walls of the sanctuary, for energy savings and comfort.





CALVARY BAPTIST CHURCH, KILLARNEY MANITOBA

In an air barrier system, polyethylene vapour barrier is sandwiched between two layers of drywall on inside walls. The strategy protects the vapour barrier by preventing drafts caused by air pressure from wind.

Sheathing on outside walls is covered with Tyvek, an air barrier material that allows vapour to pass through to the outside, helping keep wall cavities moisture-free. Tyvek also shields the interior polyethylene vapour barrier by keeping the wind out.

The combined effect of the air-barrier system helps control air leakage into and out of the building, reducing the church's heating and cooling bills and improving occupant comfort.

## Following in footsteps

The conversion from baseboard heating to a heat pump system has inspired other churches in the Killarney area, says Mark Bryce.

"I know of another church that plans on installing a heat pump system this year. A third church expects to install their new heat pump system in the near future."

Other religious institutions are turning to heat pump systems for the same reasons as Calvary Baptist Church in Killarney.

Heat pumps are an environmentally friendly form of heating and cooling, because they do not

consume natural resources. They are extremely efficient compared with conventional forms of heating and cooling.

Heat pumps also make a building so comfortable they create a welcoming atmosphere in all seasons.

## > APPENDIX C. Improving the efficiency of a heating system

Conventional heating equipment that burns fossil fuels is typically in the range of 55 to 65 per cent efficient. This is because these units have a pilot light that is always burning (called a standing pilot). They also use a natural draft venting system (draft hood) that results in a constant flow of air through the boilers or draft hood and out the venting system (chimney). When the heating system is in standby mode, heat from the exchangers is extracted by heated room air flowing through the heating equipment and carried outdoors through the venting system. This loss is referred to as stand-by loss. These conventional heating systems can no longer be purchased for homes; they can still be purchased for commercial facilities, but this is not recommended.

When a natural draft heating system is firing, it removes heated building air to the outdoors through the venting system to maintain a constant

pressure at the burners. This air is referred to as dilution air. The stand-by and dilution loss could represent five per cent to 30 per cent of the natural gas consumption for these units.

A mid-efficiency natural gas heating system is about 80 per cent efficient because it uses an electronic ignition to light the flame instead of a standing pilot. It also uses a draft fan which provides a draft only when there is a call for heat, eliminating the outmoded draft hood.

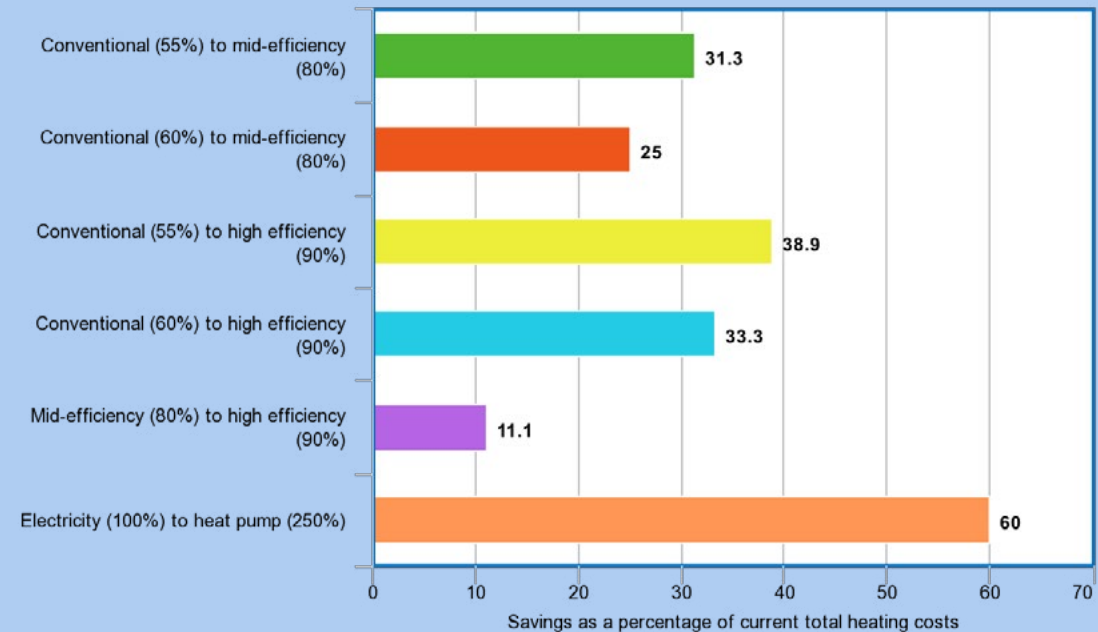
A high-efficiency natural gas heating system is between 90 and 95 per cent efficient. These units include electronic ignition, a draft fan, and a secondary heat exchanger that removes additional heat by condensing the moisture in the exiting flue gases.

Electric heating systems (boilers, furnaces, baseboards, or plug-in heaters) are considered 100 per cent efficient.

The efficiencies of all these systems do not include the efficiency of delivery or distribution, and can vary depending on maintenance and other factors.

### > Converting your heating source

How much could you save as a percentage of your current total heating costs?



Heat pumps typically have a coefficient of performance (COP) of two to three, which means that for every unit of electricity used to operate the heat pump, two to three units of heat energy are produced. This is sometimes referred to as an efficiency of 200 to 300 per cent.

Although a ground source or geothermal heat pump system can reduce the cost of heating an existing electrically heated building by 60 per cent, it is difficult to accurately predict dollar savings resulting from the conversion of

a natural gas system to a heat pump system. There are many factors involved, such as the impact of demand charges, potential rate class changes, and the actual cost of electricity (runoff or lowest block rate).

Before replacing any existing building heating system, detailed and itemized load calculations should be performed by an engineer registered with the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), or by a contractor or technologist certified by the Heating, Refrigeration & Air Conditioning Institute of Canada (HRAI) or the Hydraulics Institute.

Replacing an aging low efficiency heating system with an energy efficient unit that uses the same fuel can be cost effective, but care must be taken when converting to another fuel, particularly an electrical or heat pump system.

## Converting to electric or geothermal

Considerations to be taken before converting to an electrical or geothermal heat pump heating system:

1. A key consideration is whether your present electrical service is large enough to handle the increased load of an electrical heating system or a heat pump with a supplemental electrical heating system.
2. An electrical heating system (either conventional or heat pump) can result in a demand charge that will offset some of the savings. The charge

depends on existing electrical consumption, load factor, and the size of installed equipment.

3. Although a forced air system is easily converted to a heat pump system, heat pumps produce low temperature air at around 38°C to 43°C (100°F to 110°F). As a result, ducts for hot air distribution system(s) may have to be enlarged to ensure that the same amount of heat is available to each room.
4. Hot water systems also use high temperature hot water at 60°C to 80°C (140°F to 180°F) which is hotter than is normally produced by a heat pump system. An engineering study must be conducted to ensure existing pipes and radiators are big enough to carry the higher water flows required to maintain adequate heating capabilities.
5. Because a steam heating system uses very high heat, replacing a steam heating system with a heat pump will also require replacing all heating radiators, piping, and controls. An engineering study is required.
6. To install a closed loop system requires a large area of land, either a lawn or parking lot, to install the vertical pipes. If only a limited amount of land is available, the more expensive open loop (two-well) system can be used, provided adequate groundwater is available. An engineering study is required.
7. Setting back the temperature is not recommended when using a heat pump system because the recovery time is very long. Setting back the temperature will also cause the supplemental heating equipment to operate excessively, reducing savings.
8. Setting back the temperature when using an electrical heating system will cause increased demand charges, as all the electrical heaters will come on at the same time to bring the temperature back to normal, increasing the recorded demand.

## > About the Editing Team

Faith & the Common Good is grateful to Manitoba Hydro for their permission to copy and update the Religious Buildings Initiative: Energy Efficiency Guide for Religious Buildings document produced in 2017. Additional edits were provided by Stephen Collette and David Patterson, graphic design by Christine Boyle.

### Stephen Collette

Stephen Collette is the Building Audit Manager for Faith & the Common Good. Stephen created the Green Audit after seeing an opportunity to improve the connections between faith, buildings, and the existing passion of people to want to do the right thing within their faith community. Stephen owns his own company, Your Healthy House, which carries out indoor environmental building inspections and consulting. Stephen is a Certified Building Biology Environmental Consultant, a Leadership in Energy and Environmental Design Accredited Professional and a Building Science Specialist of Ontario.

### David Patterson

David Patterson is Faith & the Common Good's energy coordinator. David has been consulting through his company, Proterra Sustainable Solutions Inc. since 2007. He has performed over 60 audits of faith buildings for Greening Sacred Spaces' Green Audit and Solar Audit programs and has also planned and coordinated the installation of multiple geothermal, wind and solar systems on private dwellings.

### Rev. Christine Boyle

A community organizer, activist, and communications strategist, Christine is the Minister of Community Life at Canadian Memorial United Church and Centre for Peace, on unceded Coast Salish Territory in Vancouver. She spearheads Faith & the Common Good's Fossil Free Faith climate justice initiative and is helping BC faith communities connect with our faith-based environmental support network.

## > About Faith & the Common Good

Faith & the Common Good (FCG) is a national, interfaith charitable network founded in 2000 on the belief that our diverse faith congregations and spiritual communities can be powerful role models for the common good. FCG supports diverse faith and spiritual communities contribute to greener, healthier, more resilient neighbourhoods.

Find out more at: [www.faithcommongood.org](http://www.faithcommongood.org)



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Faith & the Common Good (FCG) is a national, interfaith charitable network dedicated to assist and inspire religious congregations and spiritual groups of all backgrounds to take collective action in creating more sustainable communities.

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