Energy Guidelines for the
Renovation and Construction
of
Religious Buildings

About this publication
The Interfaith Coalition on Energy has examined thousands of buildings belonging to religious congregations. Some of them are new or recently renovated, and from these, we have learned many helpful ideas for those beginning the construction or renovation process. This publication has several parts:
Part A discusses planning ahead to avoid mistakes  
Part B is a narrative of several specific aspects of energy systems  
Part C is a checklist  
Part D is a list of questions to ask design professionals

Our thanks to the now defunct Nonprofit Energy Savings Investment Program for some of the following information. We also included some information from our article in the October 1988 issue of Construction Specifier magazine.

**Part A. Planning ahead to avoid mistakes**

Congregations that serve their communities can feel compromised by owning and operating facilities that demand high payments for electricity and fuel. More dollars for energy mean fewer dollars for service.

Many lessons can be learned from older religious buildings. The annual energy cost per square foot of floor area is less in older buildings than in newer ones, mostly because the energy systems in newer buildings require more electricity for air conditioning. Very old buildings come from the era before natural gas, fuel oil and even electricity. They usually have large steam boilers, natural lighting and natural ventilation. Newer religious buildings have less mass, less natural structural material, hot water heating, air conditioning and mechanical ventilation.

If a congregation must construct a new building or expand an older one, it is least expensive to plan for a building that uses very little electricity and fuel. Plans are relatively easy to change. After construction contracts are let, however, changes can become very expensive change orders. And after the building is built, changes are even more expensive. The following are some of the mistakes congregations can make in planning for a new building or major renovation:

- Not adapting existing facilities to expanded use, to avoid construction and renovation altogether
- Not considering that electricity and fossil fuel costs will increase substantially over the life of new facilities
- Paying more attention to the purchase cost and less to the cost of ownership
- Oversight of construction falling on too few individuals
- Design professionals not working as a team

**Trends in construction**

- Fossil fuel costs may go up and down temporarily, but they will inevitably increase, at increasing rates.
- Tight and humid buildings are more likely to have problems with mold and mildew.
- Growing Asian economies and wars in which the US is involved can increase the cost and decrease the availability of building materials.
- Control systems are becoming more complicated with digital components, wireless communication and user-unfriendly interfaces.

**The building as a system**
When a congregation views their new project as an integrated system, the cost of ownership will be less. For example:

- Efficient lighting reduces the size of air conditioning equipment because lower wattage lamps and ballasts produce less heat during the cooling season.
- Increasing the insulation level and the quality of windows reduces the initial size and lifetime energy use of both heating and air conditioning equipment.

Energy Codes and Standards

Almost all new religious buildings will have to comply with mandatory life/safety codes. Other codes may apply in different states, municipalities and counties. In recent years, codes and standards have been greatly improved. Here are some of the more relevant ones:

1. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

ASHRAE created a code called Standard 90 starting in 1975. Every few years, an updated version is produced by consensus among design professionals, business leaders, the Illuminating Engineering Society of North America (IESNA) for portions related to lighting, and the American National Standards Institute (ANSI). The current standard is ASHRAE Standard 90.1-2004. ASHRAE also has a much less recognized standard for renovating existing building – Standard 100. Each standard recommends efficiency levels for various mechanical and electrical equipment, and thermal qualities of components of the building shell.

2. International Code Council (ICC)

The ICC has produced many different codes. In 2004, the Commonwealth of Pennsylvania adopted many of them to be enforced statewide. Some municipalities and counties will opt not to have their own building inspectors, in which case the Pennsylvania Department of Labor and Industry or outside professionals will provide inspection services. Not complying with an inspector can result in a warning, then a fine, and then the denial of a certificate of occupancy in Pennsylvania. When over half of a facility is renovated, the ICC rules say that the whole facility shall be brought up to code.

3. Leadership in Energy and Environmental Design (LEED)

“Green” buildings represent a departure from conventional practice in how we design, construct and operate buildings. Good sustainable building design includes high levels of energy efficiency, but goes further to lessen environmental impacts, reduce resource consumption and improve occupant health and productivity. Issues concerning indoor air quality, the recycled content and ultimate recyclability of building materials, construction waste reduction, the use of local building materials, and the impacts of design and building materials on the occupants are considered in the decision-making process.

Members of the U.S. Green Building Council developed a voluntary Green Building Rating System® called Leadership in Energy and Environmental Design (LEED), which are standards for developing high-performance, sustainable buildings. LEED standards are currently available or under development for new construction, existing buildings, homes and even neighborhoods. Buildings can qualify for various levels of compliance to LEED standards to receive ratings such as certified, silver, gold or platinum. To qualify for each stricter level of compliance, designers choose materials that are more locally-produced, less toxic, made from recycled material, and so on. The
building design is awarded points for orientation, insulation levels, quality of windows, the efficiency of mechanical and electrical equipment, etc.

From our point of view, designers and operators of religious buildings can refer to LEED to choose better materials and techniques, without incurring the sometimes substantial expense of qualifying for the actual awards. LEED’s most valuable quality, in other words, may not be the award. It may be more significant that it offers many alternatives to wasteful building design and operation that can be adopted by any designer or building operator.

4. EnergyStar®

In 1992 the US Environmental Protection Agency (EPA) started ENERGY STAR as a voluntary labeling program to identify and promote energy-efficient products. The US Department of Energy (DOE) joined the effort four years later. Categories of rated and labeled products has expanded to 40 product categories and thousands of models of major appliances, office equipment, lighting, home electronics, and more. EPA has also extended the label to cover new homes and commercial and industrial buildings. See www.energystar.gov/

5. Building energy simulation

The energy use of your planned building or addition can now be simulated by a desktop computer. One comprehensive and complicated program is called eQuest and can be downloaded without charge from doe2.com/download/equest/. It is easier, but not cheaper, to hire someone to program your construction plans into this software. The computer model can then be tweaked to design for the lowest electric and fuel consumption.

Part B. Specific aspects of energy systems

In most communities, houses of worship and the buildings associated with them are older than most building stock. As we enter an era of virtually certain increased energy cost, we should bear in mind that plans for buildings associated with religion should require extra care in design.

In the Philadelphia area, about two-thirds of the energy expense is for fuel. However, our recommendations for energy management of lighting, domestic hot water, and other non-heating related energy uses are applicable to most religious buildings. For example, an Interfaith Coalition in Arizona determined that only five percent of the energy expenses there is for fuel.

Most of our suggestions deal with invisible aspects of the building, such as system control and lamp choices. In no way is our advice a substitute for services provided by local architects, mechanical engineers and lighting engineers. There are many factors to consider in new building and major renovation design. Here are a few of them:

The building committee

Professionals will likely deal with a building committee composed of several dedicated volunteers from a congregation. Committee members may not have expertise that is found in the business sector. Instead, individual members may have a lot of emotional involvement with the building process. Structural ideals may not be balanced by knowledge of building use.

Clergy may participate in the committee, and it is helpful to remember that neither the clergy nor most committee volunteers have any formal training in facility design or operation. If a committee
is not able to make clear decisions, they may augment it with members of the congregation with more practical experience in sorting out design options. These may include a construction manager, a mechanical engineer, and a facilities manager.

Plans and specifications
There are several types of construction documents, or blueprints. Plans are drawn as if looking down at the building. Sections are drawn as if the building were vertically sliced apart along a specific line. Elevations show the vertical surfaces of the building, and detail drawings are larger scale drawings of specific decorative or structural parts.

The value of blueprints increases with their age, but as they get older and more valuable, they deteriorate. To preserve prints, a congregation could catalog them and buy special cabinets to protect them from light, fire, dirt, excessive humidity and dryness. They should be stored flat, rather than rolled up. Blueprints can also be copied onto high quality, acid-free paper, or microfilmed. While high quality paper may last 500 years, microfilm lasts only 100.

We recommend that one set of plans be backed with cloth or laminated in plastic to make them permanent. This set should be labeled “Not to leave the premises.” Only copies made from this set should be allowed to leave the premises.

With each addition or major renovation, another set of prints may become part of the congregation's legacy. Yet, upon arrival to survey the site, we may open a box of blueprints to see shards of paper pour out of their containers like thin, brittle crackers. We frequently find torn, faded paper or indications of missing sheets.

How valuable are they? To re-create them may cost $5,000 to $50,000 depending on how large and complex the building is, according to Bruce Laverty, curator of the Philadelphia Athenaeum. Their website is www.philadelphiabuildings.org. A search by the word "church" revealed 3,106 files because the Athenaeum stores prints of religious buildings without charge, and will reproduce a set of its prints for an archived congregation on request - also without charge. See www.philadelphiabuildings.org

These days, designers are likely to use computers to design buildings. Records are therefore stored in magnetic memory on disks, drives or tape. Blueprints of historic buildings, however, are like valuable artwork. They were hand-drawn by skilled draftsmen, long before computers were invented.

Badly deteriorated blueprints may be rejuvenated with the application of special liquids and then mounted between layers of Mylar polyester. Or prints can be mounted on linen. Neither of these is cheap or permanent. Lost blueprints can also be re-created by measuring everything in the building and re-drawing the set of prints. We suggest that congregations copy their blueprints to digital files, like .pdf or .jpg types.

Hours of use
There are many types of buildings in the religious community. There are residential buildings, such as rectories, convents, manses, and parsonages. The principles for design of these buildings are different than the buildings with which this article is concerned - the non-residential buildings, which include houses of worship used for worship only, houses of worship that have multiple uses,
combinations of worship and education buildings, combined church and parochial elementary school, social halls, church office buildings, modular classrooms, and so on.

There are many fewer houses of worship than residential or commercial buildings. Houses of worship require special design skills and experience in dealing with congregations. For example, heating contractors deal mostly with residential buildings because there are so many more of them. They often mistakenly apply techniques and equipment that work well in homes to buildings that are not occupied overnight.

The evaluation of the benefit for low first cost in relationship to low operating cost over time will depend, in large part, on the intended hours use of the new or renovated building. With very little use, low first cost becomes more important. With long operating hours, low operating cost becomes more important, and higher first cost for more efficient equipment and systems can be justified. For example, it is difficult to justify highly efficient boilers or double glazing on the basis of energy savings alone in a church that is used a few hours each week.

What is an efficient church or synagogue?

In general, houses of worship in Philadelphia use about two kilowatthours of electricity per square foot per year, and about one half gallon of #2 fuel oil (equivalent to 55-60 cubic feet of natural gas) per square foot per year.

Energy efficient houses of worship use about one-and-a-half, or fewer, kilowatt hours per square foot per year, and about a quarter of a gallon of #2 fuel oil (30-35 cubic feet of natural gas) per square foot per year.

Conditions during vacancy

We have seen efficient performance in churches that are used every day of the week. Efficient buildings have less to do with insulation and double glazing than with control systems that minimize energy use when the building is not occupied.

Since religious buildings tend to follow seven-day cycles of use, control systems such as seven-day clock thermostats and seven-day time clocks are more appropriate than residential controls having a 24-hour schedule.

Zoning

Measured energy data from hundreds of religious buildings shows that typical zoning of heating and cooling systems beyond three or four zones is not very effective in reducing energy use. One reason for this paradox is that many other parts of the building must be used when one zone is used. For example, for a small meeting of Boy Scouts in one room, space conditioning and lighting are needed in corridors, stairwells, rest rooms, foyers, kitchens, and other parts of the building.

Zoning can be made more effective by creating parts of the building that are completely separate from the other parts. These occupancy units have their own entrance (for handicapped if necessary) to the outside and are closed off from the rest of the building. Each can be equipped with its own rest room, small kitchenette, storage space, space conditioning systems with separate temperature control, and lighting. The use of one zone would not require the conditioning of the other zones.
Sales tax
The rules governing state sales tax should be reviewed. In Pennsylvania, for example, wall to wall carpeting is taxed, but rugs that are not permanently installed are free from tax. Lighting fixtures with plugs are tax-free, but permanent lighting fixtures are taxed.

New accounts for energy, water, sewer, and telephone in buildings owned by a congregation should be free of sales tax where possible. Tax exemption certificates and other documentation should be presented to utilities and fuel suppliers.

Some states tax kitchens as commercial portions of otherwise tax-free property. The revenue department of each state has information that can be sent to the designer and owner.

Contractors and subcontractors should not be allowed to charge for taxes which are then passed on to the congregation. A paragraph or two in the construction documents can help to prevent this.

Electric rates
When adding to an existing building there may be an impact on the cost for electricity in the existing facility if the new building is not metered separately. Both single metering and separate metering should be evaluated.

The time when the building is used may change the cost of electricity. With off-peak electric service, heavy use of the building during on-peak times may be very costly. Designers should evaluate the availability and benefits of off-peak electric rates.

Even if the building is not totally heated by electricity, there may be sufficient installed electric heat to qualify for a less expensive electric heat rate.

With deregulation, lower electric and natural gas prices may be had from third party suppliers, but the congregation will leave the protection of the Public Utility Commission. The only protection they will have will come from a contract written by the third party supplier in its interest, not the interest of the congregation.

Submetering
When a space is designed to be rented to non-congregation groups, submeters can be installed to assure fair charges for water, gas and electricity.

Choice of heating energy
Electrically heated churches in the Philadelphia are more expensive to operate per square foot than those heated by natural gas or fuel oil, even with electric heat rates and heat pumps.

Larger buildings heated by natural gas can benefit from interruptible rates offered by some gas utilities, which requires the installation of a dual-fuel burner. During extreme cold weather, the burner will automatically switch to a supplementary fuel so that the gas utility has adequate capacity for their other customers.

In 2011, the fracking of Marcellus Shale has greatly reduced the price of natural gas to about half that of #2 fuel oil.
Large fuel oil tanks
When considering oil heating systems, the cost of oil can be reduced with the installation of a larger fuel oil tank. When underground tanks are planned, careful attention must be paid to the quality of the tank and its installation. Leaking underground oil tanks are a liability for any congregation as well as the community it serves.

The larger tank will allow the congregation to request bids for larger and fewer oil deliveries, reducing the overhead of the oil dealer and reducing the price for oil.

Propane tanks
Normally, propane tanks are owed by a propane dealer who can change its price on a whim. If the congregation purchases and installs a propane tank, they can request bids from various propane suppliers.

Heating systems
Measured data from many buildings show that gas-heated buildings use slightly less energy per square foot than oil-heated buildings. Buildings with hot water, warm air and steam distribution systems use about the same amount of energy per square foot. Therefore, the type of heat distribution system should be based on criteria other than energy use.

New, experimental or unique heating and cooling systems will not, in themselves, create an energy efficient building. Systems such as solar heating, ground water heat pump, air-to-air heat pump, direct gas-fired infrared, and radiant slab heating probably should be avoided.

These technologies generally do not have a broad history of performance. They lack wide market support. Fewer contractors understand how to install and service the equipment. Replacement parts are less plentiful. Maintenance costs may be higher.

Conventional systems, such as perimeter hot water, perimeter steam, or warm air, should be considered. With commonly installed systems, there is broader market support, wider choice of products and ready stocks of replacement parts. It is more likely that mechanical contractors will have more experience with their installation and maintenance.

The rated efficiency of new equipment has little relevance if that equipment is installed poorly. Therefore, the specification for the installation of mechanical systems should contain some measured standard of performance.

Final payment to heating contractors should be contingent on the installer attaining a specified measured efficiency. For example, with a gas-fired boiler or furnace with a power burner, the measured steady-state efficiency could be specified as 84% or greater with a net stack temperature less than 370°F., no smoke or carbon monoxide, and CO₂ greater than 10%.

Heating capacity
Heating load estimates and the resulting heating capacity per square foot of buildings in our database varies more widely in non-residential buildings than in residential buildings. The table below shows data from 60 non-residential buildings. The heating capacity in BTU input per square foot is listed in relation to the amount of energy used per square foot.

<p>| Input Heating Capacity and Non-residential Heating Energy Use |</p>
<table>
<thead>
<tr>
<th>Capacity in BTU/SF input</th>
<th>Number of Bldgs.</th>
<th>Fuel in BTU/SF/Yr</th>
<th>Fuel Full load hours</th>
<th>Electric Hours use of demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40</td>
<td>8</td>
<td>40448</td>
<td>1445</td>
<td>122</td>
</tr>
<tr>
<td>41 to 60</td>
<td>7</td>
<td>53322</td>
<td>952</td>
<td>119</td>
</tr>
<tr>
<td>61 to 80</td>
<td>10</td>
<td>52456</td>
<td>896</td>
<td>140</td>
</tr>
<tr>
<td>81 to 100</td>
<td>12</td>
<td>53605</td>
<td>560</td>
<td>123</td>
</tr>
<tr>
<td>101 to 120</td>
<td>10</td>
<td>57070</td>
<td>524</td>
<td>114</td>
</tr>
</tbody>
</table>

The hours use of demand is the annual average use of the monthly peak electric demand. This is derived by dividing the monthly kilowatthours by the peak kilowatts, and is some indication of the hours that the facility is used. Note that these buildings have approximately the same hours use of demand. Therefore, the variations in BTU/SF/Yr in the above table are not related to varied hours use of the buildings.

Heating systems in these Philadelphia buildings with less than 40 BTU/SF of capacity clearly had lower energy use than those with average and above average capacity. As the heating capacity per square foot increases, the amount of heating energy increases. Therefore, it is important that a heating system with the smallest practical heating capacity be installed.

Since temperatures can be set back steeply in non-residential buildings, the capacity of the heating system should be adequate to quickly recover from low temperatures during unoccupied periods.

**System configuration**

An alternative to specifying commercial heating and cooling systems is to use residential systems. For example, a pair of smaller hot water boilers or furnaces with different fuels would allow for lead/lag switching based on efficiency and fuel price. There are greater product selection, lower repair costs, and often simpler configurations with residential systems.

With multiple boilers, a more expensive, higher efficiency unit can be installed to carry most of the heating load, while a standard unit can be installed for recovery from night temperature setback and for cold days. This same principle can apply to air conditioning systems.

One of the heating systems could be gas and the other oil. The lead system could be fired by the cheaper fuel.

With pairs of heating systems, cooling system or pumps, we do not recommend cycling the firing order so that both units have equal hours of operation. Redundant pairs were installed for reliability. Using one heavily to the end of its life leaves the other, lesser used one as more reliable insurance.

Boilers: When installing a boiler system, consider the use of multiple modular boilers to better match the varying loads. Packaged Roof-Top Units: Specify high efficiency equipment (EER 10 or more) and units with an economizer cycle for free cooling.

Split System Air Conditioners/ Heat Pumps: Specify units with a high efficiency. Units below 5.4 tons, specify a minimum SEER of 13. Units over 5.4 tons, specify a minimum EER of 10. 1) Specify high efficiency furnaces (natural gas - AFUE 90% or more; fuel oil - AFUE 85% or more). A furnace or boiler that condenses flue gases is more appropriate in a worship space because the
congregation can avoid the expense of lining a relatively large chimney by venting through the wall. Also, since the air returning to furnaces can be cold, the heat exchangers in condensing furnaces will last longer than lower efficiency units that require chimneys.

Insulate all steam and hot water pipes in unconditioned spaces – 1 inch self-jacketing fiberglass for hot water; 1½ inches for steam.

All ducts should be gasketed between sections or sealed with mastic (do not use duct tape). Avoid fiberboard ducts and flex duct. If flex duct is used, it should be used only in runs under 10 feet. Specify low leakage dampers on all applicable systems. In some cases where large amounts of ventilation are required, heat recovery ventilators can be used to pull the heat out of the outgoing air stream.

Since worship spaces are usually unoccupied more than they are occupied, equipment should include controls to close down the system when the building is vacant. This could include timers or interlocks on exhaust fans, motorized dampers on outside air intakes and controls to turn off equipment operating unnecessarily.

**Temperature Controls**

Our best success in achieving energy efficiency involves the use of proper controls. Seven-day clock thermostats, with each day separately programmable, are clear winners. For larger buildings that are used several days each week, we sometimes recommend optimal time start control. Quite often this is part of the software in digital clock thermostats and is called “intelligent,” or “ramped” recovery.

We recommend setback space temperatures as low as 45°F in buildings unoccupied for more than one day per week. Freeze protection thermostats can protect water from freezing in pipes, and should be wired in parallel back to the heating system to create a fail-safe condition.

In other words, the temperature during occupied times can be controlled by a typical wall thermostat. The temperature during unoccupied periods can be controlled from the places where there is the maximum risk of freezing water in pipes.

Pipe organs are not generally harmed by low temperatures. ICE polled the opinions of twenty-two members of the Associated Pipe Organ Builders of America and they all agreed that temperatures as low as 45°F would not harm these valuable instruments. However, the organs must be played at the same temperature as that at which they were tuned. Copies of the report on this research are available from ICE on request.

Pianos, on the other hand, can be harmed by great temperature fluctuations. ICE suggests that low-wattage, thermostatically controlled heaters be installed in pianos. Especially designed heaters, called “chill chasers,” are sold by piano dealers. The pianos can also be covered with thick protective quilts.

Controls commonly used for multifamily and other residential buildings are usually not appropriate for use in parochial schools or houses of worship. For example, outdoor temperature reset for constant perimeter circulation of hot water is common in multifamily housing. In infrequently-used buildings and spaces, however, outdoor temperature reset limits heating system output during moderate weather, preventing quick recovery from low interior temperatures during unoccupied periods.
The same is true of pairs of hot water boilers, one of which is controlled by the setting of a thermostat sensing outdoor temperature. We recommend staging the boilers on return water temperature instead.

Seven-day time clocks or clock thermostats should be used to control electric heaters and unit ventilators. We suggest that toilet exhaust fans be interlocked with light switches.

We advise against overly-complicated controls, such as energy management systems or proprietary control systems for which software or replacement parts come from only one source. Such control systems often require contractors to make changes, for a fee, that members of the congregation could make, if the more user-friendly controls had been chosen in the design of the mechanical systems.

**Boiler controls**

We suggest cold starts for boilers. In other words, the boiler should not maintain water temperature or steam pressure when there is no demand for heat. This is accomplished with double-pole relays or valve end switches.

Boiler shock, which is the introduction of damaging cold water into a hot boiler, can be avoided in two different ways. First, in systems with a single circulator and room thermostats controlling zone valves, water can be constantly circulated when the outdoor temperature is below 37°F. The circulator can be controlled by a time clock in parallel with an outdoor thermostat. The burner would be controlled by a space thermostat.

Second, a time delay relay can be installed in the burner circuit so that the water is mixed by the circulator before the burner fires. Any such control should be prominently labeled to avoid confusion.

**Free cooling**

Many older churches and synagogues had provisions for ventilation during the summer. There often were openings in the ceilings of the buildings that were designed to relieve heated summer air so that cooler outdoor air could be introduced in the lower parts of the building. There were windows which could be opened.

Some newer houses of worship are sealed up tight. There are no openings high in the nave ceiling. Windows in the lower parts of the building are often designed to remain shut, or are covered by a second layer of fixed glazing. These designs have compromised both comfort and air quality.

We observed one church which had a wonderful summer ventilation system with many windows that could open. The congregation covered the windows with fixed, rigid plastic, and is now contemplating an expenditure of $130,000 for central air conditioning.

The heated air in the attic space between the ceiling and the roof needs to be vented. Such ventilation removes moisture in the winter, and heated air in the summer.

Philadelphia, for example, gets hot in the summer. More and more congregations are installing central air conditioning. Others have re-discovered that old-fashioned, yet effective, ventilation is one key to comfort, indoor air quality, and lower energy costs.
Lighting

All four-foot fluorescent fixtures should use 32-watt T8 tubes with a color rendering index (CRI) of 84 or more. Electronic ballasts in fluorescent fixtures should be specified in detail to ensure quality materials. Avoid the use of 2x2 fluorescent fixtures because their tubes are expensive. Use four foot single-tube fluorescent fixtures where applicable even though they cost the same as four foot two-tube fixtures.

Utilize compact fluorescent fixtures for recessed cans, wall sconces, table lamps, pendants, and other wall/ceiling fixtures. Specify high power factor ballasts in all compact fluorescent fixtures.

LED exit signs use just a few watts and last for 25 years or more. While the payback is generally longer than using compact fluorescent exit signs, the maintenance cost reduction more than makes up the difference in the long term.

Mercury vapor lights for outside lighting are considered obsolete, and should be high pressure sodium or metal halide lamps. High intensity discharge lamps should be used with caution. The congregation may wish to present a warm image to the community and may be disappointed when their house of worship is illuminated by cool blue lighting.

No standard 120-watt PAR floodlights should be specified because the new tungsten-halogen floods, such as the Capsylites from Osram/Sylvania or Halogen IR floods from GE, cost about the same, have the same light output and longevity and have less lumen depreciation over the life of the lamp.

Avoid outdoor lights that are rented or leased from the utility. Similar lights mounted on the building and owned by the congregation are usually less expensive than those from the utility. Local politicians can be petitioned for additional street lighting in high vandalism areas.

The outside lighting can be controlled by both a time clock and photocells rather than by photocells alone, so that the lights can be turned off when they may not be needed early in the morning.

The lights inside the house of worship should be installed so that the bulbs can be changed conveniently. The lower the light fixture, the more light will shine on hymnals. Care should be taken not to install ceiling fans between lights and the pews. The moving blades will flicker the light.

The Illuminating Engineering Society, under pressure from ICE and others, has changed its suggested 10 to 30 footcandles in the house of worship to a more realistic 4 to 5 footcandles prevalent in traditional naves. Older people and darker-surfaced spaces may need more light.

Typical pendant fixtures in the house of worship have lower and upper lamps, frequently of equal wattage. Footcandles at hymnal height are not influenced greatly by the upper lamps in pendant fixtures. Consideration should be given to using lower wattage lamps in the upper parts of the lamps, merely for decorative purposes. The more important, task-related lights are in the lower parts of the pendant fixtures.

Some manufacturers offer compact fluorescent lamps up to 105 watts, which produces lumens similar to a 500-watt incandescent lamp, but has up to ten times the life. Such lamps are often justified by the cost of scaffolding alone, which would be required one tenth as often. Most compact fluorescent lamps cannot be dimmed, but some can. We suggest experimenting with several before purchasing a large number.
Lighting levels in classrooms are adequate at 50 footcandles. The amount of light desired by a particular congregation should be determined by preference, not by societal standard. With the advent of T8 tubes and electronic ballasts, one for one replacement of standard T12 34-watt tubes can cause significant overlighting, meaning that some tubes and/or fixtures can be removed or relocated.

Domestic Hot Water
Choose the least expensive available energy source for the water heater. Gas is generally less expensive than electricity.

We recommend domestic hot water no hotter than 110°. If gas is available, we suggest a high efficiency gas-fired, storage-type hot water heater, or instantaneous water heaters with controllable discharge water temperature.

We recommend additional insulation blankets on all electric hot water heaters installed before 1992. For electric hot water heaters installed in buildings that are billed with demand charges, we suggest that a 7-day time clock be installed so that domestic hot water is heated during off-peak periods and the electricity shut off during on-peak hours.

If the congregation desires constantly circulating hot water so that hot water is immediately available at all sinks in the facility, then a 7-day time clock should be installed to turn off the circulating pump when the building is not occupied.

Specify non-atomizing water-saving showerheads for showers that will be frequently used.
Summer/winter hookups for heating domestic hot water in the same boiler used for space heating are discouraged. Our measured energy data show that non-residential buildings with summer/winter hookups use about 2% more fuel than those which have separate hot water heaters. Residential buildings use about 6% more energy with summer/winter hookups.

Appliances
If the congregation desires to have electric water coolers, specify that the contractor adjust the thermostats for 55° or higher water temperature.

Choose the least expensive available energy source for cooking. Natural gas and propane ranges should be equipped with electronic ignition.

Refrigerators and freezers are often empty between social events. The type of appliances and the method of control should be taken into consideration in the design process. For example, several smaller appliances may be more efficient than one larger one. Most of these could remain empty and turned off between uses.

We use P3 Kill A Watt meters to determine which residential style refrigerators and freezers are worth replacing. These small, accurate meters are available most cheaply ($28) from www.supermediastore.com. Top freezer refrigerators are more efficient than side-by-side models. Chest freezers are more efficient than upright models. To see many alternatives, visit www.sears.com. Most refrigerators and freezers listed on that site have the yellow appliance electric consumption label available with the click of your mouse.
Purchase computers, printers and copiers with the E.P.A.'s "Energy Star" designation. Energy Star equipment incorporates a "sleep" function which powers down the machine during periods of inactivity. Use laptop computers instead of desk-top microcomputers. Lap-tops use only 10% to 20% of the energy used by desk-top models.

Purchase ink jet printers instead of laser printers. Ink jet printers use up to 95% less energy. Use plain paper ink jet fax machines instead of thermal paper or laser fax machines. Purchase solar desk top calculators.

Horizontal axis, front load clothes washers are more efficient than top load washers. In most cases, clothes dryers, cooking equipment, and dishwasher booster heaters should be fired with natural gas rather than electricity.

Central station coffee makers with vacuum carafes should be used instead of individual coffee makers.

**Not Recommended**

a. We do not recommend using ceiling fans during the heating season for several reasons. Our measurements during the heating season in Philadelphia reveal little stratification of air temperature in intermittently-heated buildings. There seems to be a natural air convection that gently mixes the air during recovery from night setback.

   In hot climates, there is a lot of stratification in sanctuaries during the cooling season. The fans increase the temperature of the air at the level of the congregation by blowing down the hot air near the ceiling.

b. We do not recommend new and unproven technologies that have no proven track record of reducing energy costs for congregations.

c. We do not recommend 130-volt incandescent light bulbs because the light output is so low in relation to the wattage. Instead, consideration should be given to screw-in fluorescent lamps or fluorescent fixtures with efficient tubes and electronic ballasts.

d. We do not recommend unvented gas-fired infrared heating systems. It is clear that these systems are efficient, but they add the products of combustion to the air, including humidity which can condense on cold surfaces, causing discoloration and peeling paint.

e. We do not recommend thermostats with permanent occupied and unoccupied settings. Instead we suggest thermostats with adjustable temperature settings instead. Occupant comfort is not determined by dry-bulb temperature alone. On cold windy days, the occupants may prefer warmer room temperatures.

f. We urge designers to consider simple control systems that are easy to understand and operate. Elaborate energy management systems work best in complex and energy-wasteful buildings. Automation requires a congregation member who understands the automation. We have seen many energy management systems that have been ‘orphaned,’ or no longer supported by their manufacturers or that cannot be maintained by contractors.

g. We do not recommend non-electric radiator valves because they are susceptible to vandalism, and are unnecessary on properly-sized radiation. Certainly, if more than half the radiation in a
building needs such valves, the overheating is likely caused by bad steam traps, needlessly high boiler temperature and pressure settings. Adjustments to the entire system may be more effective than non-electric thermostatic valves.

h. We do not recommend reflectors for fluorescent troffers. The shiny surfaces may become dull when they are covered with dust, making them no more reflective than the white surfaces inside the troffers. Reflectors tend to concentrate light under the fixtures in which they are installed.

Operating manual
Congregations are different from other groups of people. There is a relatively quick turnover of clergy and building committee personnel. One way to provide continuity for building operation and maintenance is to create a manual that contains all the specifications for equipment, warranties, and names of the installing contractors and suppliers. The manual can show locations of meters, gas lines, sewage systems, and wiring to exterior lights.

The manual can also contain photos of the building under construction, particularly trench work, underground drainage, exposed wall sections and other items that will be subsequently covered.

Reduced copies of sections of the as-built plans should be put in this book, along with the specifications for the heating and cooling systems and the manufacturers’ suggestions for maintenance of all equipment. Design professionals can assist congregations in the development of such a manual.

Maintenance personnel
Proper maintenance is essential to conserving energy in the long term. The building should be designed with future maintenance in mind. Easy access to equipment should be designed into the building from the beginning. The major components of the mechanical and electrical systems should be well labeled.

Upon completion, the new building will likely be maintained by a custodian. We suggest that this person become familiar with the building during the final stages of construction. He or she can become familiar with the structure and its systems while the pipes, wires and ductwork are exposed.

When the building is finished, this person will have a more detailed understanding of how the mechanical and electrical systems are installed, and will be better able to operate and maintain them. Photographs or DVDs of these areas will be helpful for newly-hired building managers.

Building Shell

*Building Form* - A building's shape and size will affect its heating and cooling loads. Buildings with a compact form generally require less energy for heating and cooling than buildings which ramble and sprawl.

*Building Orientation* - Proper orientation can often reduce energy costs no extra cost. Building orientation on the site should respect the path of the sun. The long axis of the building should be oriented east/west to minimize solar gain in the summer and maximize solar gain in the winter. Windows on the north and west sides of the building should be minimized.
Air Infiltration - Reducing air infiltration is equal in importance to adequate insulation levels in reducing building heat loss. Thermal by-passes account for the majority of heat loss due to infiltration. Many areas of high air infiltration are not located in the exterior walls but in the interior of the building. These are typically hidden areas such as interior wall cavities, chases for plumbing, electrical and HVAC, and suspended ceilings. These areas should be sealed or thermally isolated during construction.

Insulation - Determining the optimum level of insulation in commercial buildings is a complex process. One key factor is whether the building's loads are dominated by skin loads (typically one story, smaller buildings where the interior climate of the building is primarily influenced by the flow of heat through the building envelop or skin) or by internal loads (usually large, multi-story structures where the loads are primarily influenced by internal sources of heat gain such as people, lighting, and office equipment). Skin load dominated buildings require more insulation than internal load dominated buildings. The minimum level of insulation in commercial buildings is contained in ASHRAE 90.1. Many very energy efficient buildings exceed these levels by a factor of 2 to 3.

Because they are ineffective at stopping air flow, suspended ceilings should not be treated as a component of a building's thermal envelop. Do not place insulation on top of a suspended, grid-type ceiling. Use blown insulation instead of fiberglass batts where possible. fiberglass batts, unless perfectly installed, do not provide optimal thermal performance. The performance of blown insulation is also better at reducing air infiltration and thermal by-passes. All curbing for HVAC equipment, ventilation equipment and skylights should be insulated.

Windows - Windows should have low-e glass and an overall U value of 0.40 or less. The U values should be for the entire window, including the frame, and not a center-of-glass value. The U value should be certified by the National Fenestration Rating Council (NFRC) using the NFRC procedures for determining the thermal performance of windows. Specify a low solar heat gain coefficient on west facing and possibly south facing windows. The type of window selected will have an energy impact. Fixed windows have the best energy performance when the interior spaces are conditioned year-round. However, most people prefer windows which open, and with proper design, operable windows can provide comfortable temperatures in the spring and fall without air conditioning or heating. Of the operable window types, casements will perform better than double hung or slider types. Minimum window thermal and air infiltration standards are contained in ASHRAE 90.1.

Doors - Install insulated doors where possible with a minimum U value of 0.2 or less. Minimum air infiltration standards are contained in ASHRAE 90.1.

Conclusions
The gathering of a group of people for worship never requires a church, temple, synagogue or mosque as we presently build them. And there certainly is no Biblical justification for wasteful building use within the religious community. America is entering an era of increasing energy cost, and now has a great deal of experience with constructive solutions to energy waste in buildings.

Early in its history, ICE learned that buildings themselves do not waste energy. Congregations must learn how to more wisely use the buildings they have inherited, and to build structures that are a legacy, rather than a curse, for future congregations.
Given the wide variety of choices that architects, engineers and specifiers can now make about building styles, construction materials, and system control, it is in everyone’s best interest to examine the options, and to pick the ones that have proven performance.

We also would like to hear any suggestions that you may have. Since we measure energy use in many buildings, we can analyze the energy used by religious buildings whose designers have taken different approaches to lowering the future energy costs for congregations.

**Part C. Checklists**

**Basic Design Process**
- □ Commit to incorporating energy efficiency into the building early in the design phase. Make energy efficiency a shared concern for all members of the design team.
- □ Evaluate design and equipment alternatives on a life-cycle cost basis.
- □ Perform a computer simulation to determine the optimum combination of energy efficiency measures.

**Building Shell**
- □ Determine the optimum building size and configuration.
- □ Proper building orientation.
- □ Seal all thermal by-passes.
- □ Insulate to levels greater than recommended in ASHRAE/IES Standard 90.1-2004.
- □ Do not insulate directly on top of suspended ceilings.
- □ Do not install fiberglass batts between roof rafters of a peak roof without an air barrier.
- □ Use blown insulation instead of batts where possible.
- □ Insulate all curbing in roof penetrations where part of the thermal envelop.
- □ Install low-e glass windows with an overall U-value of 0.4 or less. The U value should be certified by NFRC.
- □ Specify a low solar heat gain coefficient on west facing windows.
- □ Casement windows outperform single or double hung or slider type windows.
- □ Adhere to minimum air infiltration standards contained in ASHRAE 90.1 for windows and doors.
- □ Install insulated doors with a minimum U value of 0.2 or less.

**Lighting**
- □ Design to the proper light level. Do not over-light spaces.
- □ Specify efficient light sources appropriate for the task.
- □ Incorporate lighting controls into the design.
- □ Install high quality lamps with high color rendering.
- □ Consider a task/ambient lighting system.
- □ Use a good lighting specification for energy efficient components and design.
- □ Use point-by-point design programs instead of the lumen method.
Select light colored surfaces on walls, ceilings, and furnishings.
Comply with the lighting provisions of ASHRAE/IESNA 90.1 as a minimum.
Use T8 fluorescent tubes (84% or higher CRI).
Specify electronic ballasts in fluorescent fixtures.
Avoid the use of 2x2 fluorescent fixtures.
Use fluorescent fixtures with the fewest number of tubes necessary for adequate lighting.
Install compact fluorescent fixtures instead of incandescent.
Specify high power factor ballasts for compact fluorescent fixtures.
Use tungsten halogen instead of incandescent lamps where compact fluorescents are ineffective.
Do not use mercury vapor lamps; substitute high pressure sodium or metal halide lamps.
Use high pressure sodium lamps for exterior security lighting.
Use metal halide or T5 fluorescent lighting in high ceiling areas and outside where color rendering is important.
Use LED exit signs.
Install lighting switches in convenient and accessible locations.
Divide large rooms into several lighting zones.
Install motion sensor controls where applicable.
Install adjust switch timers in infrequently used spaces where lights may be left on by mistake.

Electrical Equipment

Purchase EnergyStar® computers, printers, and copiers.
Purchase laptop computers.
Use ink jet printers instead of laser printers. Purchase ink jet fax machines.
Purchase energy efficient refrigerators, freezers, clothes washers, dishwashers, etc.
Specify top freezer refrigerators instead of side-by-side models.
Specify chest-type freezers instead of upright models.
Specify horizontal axis clothes washing machines.
Use gas-fired clothes dryers, cooking equipment and dishwasher booster heaters.
Purchase a central station coffee system using vacuum carafes.
Purchase solar desk top calculators.

HVAC

Properly size HVAC equipment. Avoid over-sizing.
Perform a life cycle costing on several HVAC options to determine the best system over the long term.
Avoid electric resistance heat in any form.
Consider modular boilers.
Specify high efficiency units for packaged units, split systems, heat pumps, and furnaces.
Packaged units should have an EER of 10 or more.
Packaged units should have an economizer cycle.
Split systems/heat pumps under 5.4 tons should have an SEER of 13 or more.
Split systems/heat pumps over 5.4 tons should have an SEER of 10 or more.
Gas-fired furnaces should have an AFUE of 90% or more.
Oil-fired furnaces should have an AFUE of 85% or more.
Water source heat pumps should have an EER of 12 or more.
Consider unconventional HVAC equipment if life cycle cost is low.
Insulate all hot water and steam pipes.
All ducts should be gasketed or sealed with mastic.
Avoid fiberboard ducts and flex duct. If used, flex duct runs should not exceed 10 feet.
Use programmable thermostats or timers to regulate unoccupied temperature.
Consider demand limiting controls.
Consider an energy management system very carefully.
Zoning can be an effective control strategy in many buildings.
Ventilation equipment should be off or closed when the building is unoccupied.
Specify low leakage dampers.
Areas with high rates of ventilation and long hours of use could be candidates for heat recovery equipment.

**Plumbing**

Select water heaters with an high energy factor. Gas water heaters should have an efficiency factor (EF) of 0.62 or greater. Electric water heaters should have an EF of 0.93 or greater. Oil water heaters should have an EF of 0.60 or greater.
Avoid electric water heaters.
Use instantaneous water heaters in place of long pipe runs.
Avoid tankless coils in boilers without other summer loads.
Specify showerheads with a flow rate of 2.5 GPM or less.
Specify bathroom faucets with a flow rate of 1.0 GPM or less.
Specify toilets with a flush of 1.6 gallons or less.
Specify urinals with a flush of 1.0 gallons or less.
Install the smallest practical size water meter.

**Part D. Questions for design professionals**

The following are a series of questions which can be asked of design professionals to assist them in providing plans for buildings that tend to have less harmful impact on the environment:

**Section 1 -- General Questions**

**Basic overall issues**

Does the building need to be built? Can the congregation rehabilitate an existing structure instead of building a new one?

Is the land suitable for development? Is the planned building the best use of the site? What is the future of the surrounding land? Are plans consistent with the needs of the community?

Can the building be designed to share space with other congregations?

Can the building and/or major interior and exterior spaces be designed to serve several purposes, with movable seating rather than fixed pews, for example?
What is the anticipated life of the building’s major components?

Are choices of methods and materials based on life-cycle cost rather than only first cost?

What simple payback period or minimum return on investment is acceptable to the congregation?

Has the intent of the congregation to build with minimal environmental impact been communicated clearly to the architects being considered for design work?

What is the track record of the architects with environmentally-sensitive buildings? Have any members of the congregation visited those buildings?

Will the building be smoke-free?

Will the congregation children be asked what design options they favor?

Will the building be easily converted to other uses if necessary?

**Basic design issues**

Will the building’s design conform to Certified, Silver, Gold or Platinum ratings from the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System? For details about this rating system, see [http://www.usgbc.org/programs/leed.htm](http://www.usgbc.org/programs/leed.htm)

Is the design in compliance with the Americans with Disabilities Act?

Are separate areas (zones) of the building directly and easily accessible, complete with rest rooms and kitchenettes so that small gatherings will not require larger sections of the building to be open for occupancy?

**Relating to the out of doors**

Will the interior and exterior layout of spaces be influenced by the path of the sun, prevailing winds, and other environmental factors?

Will it be easy to worship outside?

Does the design of the building allow for natural light while minimizing heat loss through glazing?

Will there be a garden outside?

Will there be natural interior ventilation?

Will there be adequate shade from trees during the summer and windbreaks in the winter?

Will there be a minimum amount of lawn and maximum amount of natural habitat which requires minimal maintenance? Will native plants be used?

Is there a plan for easily and conveniently composting kitchen and yard waste?

Where will natural plants and flowers grow inside?

What happens to the storm water run-off from the roofs and paved surfaces?

**Section 2 -- More Specific Questions**
**Relating to transportation**

How will the location and orientation of the building design lend itself to ease of use of bicycles, walking, carpooling and mass transit?

Will parking lots have more than one function?

Can open block pavers or a porous asphalt surface be used instead of impermeable asphalt?

Will space be available to pile snow after a large storm?

**Choice of materials**

Are materials with proven performance being selected?

Will the embedded energy content of various materials be considered?

Will you favor locally-produced materials?

Will sales tax be avoided on all purchases? Are there phrases in the construction contract that prohibit the contractors and subcontractors from claiming exemption from state sales tax and not passing the savings onto the congregation?

To what extent can recycled or used materials be incorporated into the structure?

Will the thermal envelope be optimally insulated -- windows, doors, walls and ceilings?

Given the concerns with indoor air quality, are low toxicity materials being chosen -- paints, carpets, cabinetry and adhesives for example?

Does any of the wood come from forests the congregation wishes to protect?

Will office furnishings and equipment be chosen according to minimal energy use and environmental impact?

**Heating issues**

If solar heating is being planned, what measured data, showing the actual benefit of solar heating from existing installations in similar buildings, justify the expense?

Will the heating system be the correct size and capable of efficient part load performance?

Is electric heat eliminated from consideration if it is more expensive than fossil fuel alternatives?

How will outside air ventilation be controlled?

If a hot water heating system is being considered, how can interior temperatures during unoccupied periods be kept very low without causing a danger of freezing water in pipes? How can the danger of thermal shock to the boiler be minimized?

Will the heating systems be easy to control, avoiding complicated electronic control systems that require thick manuals in order to operate them?

Will the clock thermostats have ramped or intelligent recovery? Is each day individually programmable from all the others on a 7-day cycle?
Will the heating controls allow interior space temperatures as low as 45°F when zones or the entire building are not occupied during the heating season, with protection from freezing water in pipes?

Are the controls designed to conveniently override temperature setback, with automatic restoration of setback after one or two hours?

Will the heating systems be easy to understand, with all major pipes, ducts, and pieces of equipment labeled clearly?

Will the boiler be wired for cold starts so that the burner does not maintain pressure or temperature when there is no call for heat from any thermostat?

If outdoor temperature reset is used as a way to control water temperature, what method will be used to assure quick recovery of interior temperatures from night setback?

Will the heating systems be easy to maintain, with easily accessible filter banks, for example?

Will new, cutting-edge technology be avoided in favor of equipment that has a long-standing track record of reliability and ease of operation?

**Lighting issues**

What daylighting strategies will be followed?

Will the lighting design in the worship space vary significantly from the average light level (about 4 to 6 footcandles at hymnal height) of traditional worship space?

Will the lighting designed for other spaces not exceed illumination standards from the Illuminating Engineering Society?

Will the exit signs use light emitting diodes for the light source?

Will fluorescent tubes be T8-type with electronic ballasts? The tubes should be Series 8 (85% + CRI and 3500°K color temperature.

Will all the socketed lamps be of efficient types, such as compact fluorescent lamps and tungsten-halogen flood lamps?

Will the switching of lights lend itself to maximum use of daylight?

Will vacancy sensors be installed in areas in which lamps may remain lit when the space is not occupied? Vacancy switches must be turned on and turn off automatically. Occupancy switches turn on and off automatically.

Will all outside lighting be either metal halide or high pressure sodium fixtures with shields to prevent outward or upward glare? Will quartz and mercury vapor lighting be avoided entirely?

Will outside lighting be controlled by timer with battery back-up, rather than by photocell?

**Air conditioning issues**

Will air conditioning be avoided wherever possible in preference for natural ventilation?

How environmentally benign are the refrigerants specified for the cooling system?
If air conditioning is planned, does it have economy cycle to take advantage of outdoor air for cooling without using the compressors when conditions permit?

Will the air conditioning system be capable of economical part load performance, with variable speed fans and multiple compressors, for example?

Will the air conditioning system be easy to maintain and understand?

Will the roof be a light reflective color to reduce air conditioning loads?

Will ceiling fans be installed for cooling?

Utility and fuel issues

What is the anticipated annual electric and fuel costs for the building?

What is the most favorable electric rate for the building (off-peak, for example)?

Will the utilities understand that the building is tax exempt?

Should electric submeters be installed to measure major loads, such as air conditioning?

Should electric service be combined with other buildings to improve load factor?

Should the heating system be dual-fuel with an interruptible gas rate?

If a fuel oil tank is being planned, should it be of greater size to take advantage of bulk purchasing and extended cold spells?

Can the facility benefit from lower cost transportation gas? Should gas service is combined with that to other buildings to take better advantage of lower priced gas?

Will the offices be wired for future telecommunications?

Are there plans for an adequate number of telephone lines throughout the building?

Is the steeple being considered for a wireless antenna location to be leased? If so, is the congregation considering the profit-making and historic preservation issues?

Maintenance issues

Will information on each major piece of equipment be permanently filed in some accessible manner?

Is maintenance information on each major piece of equipment summarized in a preventive maintenance schedule?

Will a complete set of blueprints and shop drawings be mounted on durable materials and labeled so that they can always remain on-site for future use?

Will copies of the blueprints be reduced to a convenient size for those who wish to remove a copy from the premises?

Will a complete set of the specifications be kept on the premises and easily accessible for future use?
What provisions are planned for making it easy to recycle paper, plastic and metal?

**Water issues**
Where will the building's water come from and where will waste water go?
Will run-off from paved surfaces diminish the water quality of any natural stream?
Will landscape watering be minimized?
Does there have to be heated domestic water in the building?
Will summer/winter, immersed-coil, domestic water heating systems be avoided?
Will the least expensive fuel be chosen to heat water?
If electric water heaters are chosen and the facility billed according to an electric rate with measured demand, will a time clock be installed to heat water during off-peak times?
Will the temperature of domestic water be 110°F or less?
Is there a heat trap planned for the water heater's discharge water pipe?
Is flow restriction planned for each point of use?
Are water-saving toilets planned?
If domestic hot water will circulated with a pump, will the pump be timed so that water is not circulated when the building is not occupied?
Is any planned water meter oversized?

**Appliance choices**
Will appliances be chosen according to life cycle cost rather than first cost?
Does water from any planned water fountains need to be electrically chilled, or will unchilled water be adequate?
Will efficient refrigerators and freezers be chosen? Can they be easily unplugged when they are not in use?

**Kitchen choices**
Will the cabinets for the kitchen have adequate storage capacity for non-disposable dinnerware?
Will the least expensive fuel be chosen for cooking?
Is a booster heater necessary for the dishwasher? If so, does it have to be an electric booster?

**Other things for the congregation to consider**
Will the person who will be in charge of maintaining the building pay attention to how it is built?
Will he or she be on-site to witness the construction?
Will pictures and/or videotape be made of critical aspects of the building process, such as drainage from foundations, wiring in open walls, location of pipes underground and within walls and ceilings?