

Energy Audit for the Unitarian-Universalist Society of Sacramento



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1 Audit Overview

This energy audit was conducted to determine ways to make the Unitarian Universalist Society of Sacramento (UUSS) campus as energy efficient as possible. A walk-through audit was performed to identify obvious areas that could use improvement. The two buildings on the campus were investigated and a matrix of Energy Savings Opportunities (ESOs) was created that shows priority, impact and estimated cost where possible. Energy bills were also analyzed for historic energy use patterns and to estimate the impact of the improvements, and compared to the energy use of the average worship building of similar size. The goal kept in mind during this audit was to reduce the energy consumption of the campus with low cost measures, and to lay out options for a long term plan to achieve maximum energy (and related energy cost) savings.

The conclusions and recommendations of this study are based on limited information. A complete audit would require the installation of metering and monitoring equipment to better identify the sources of energy use. The recommendations section puts the most weight on the issues that will have the greatest impact.

2 Energy Fundamentals

This section is meant to familiarize the reader with the vocabulary and technologies of building energy issues. The following subsections define the terms used in the building energy field and discuss the building systems that affect energy consumption.

2.1 Definitions

The following definitions are included to help clarify the terminology used when discussing energy matters. Please use this list as a reference when reading the report.

- Aquastat – A control device like a thermostat that measures water temperatures. An aquastat may be used to cycle recirculating DHW pumps on and off based on returning water temperature.
- Building Envelope – The exterior walls, windows, roof and doors of a building. May or may not include slab/floor.
- Combined Hydronic – A water heating system that serves for both domestic hot water (showers and faucets) and space heating.
- Condenser Unit - Portion of a conventional air conditioning system that sits outside of the building. This usually contains the compressor, condenser and expansion device of an AC system.
- Condensing Furnace or Boiler – A gas burning furnace or boiler uses rust resistant materials to harvest heat from the exhaust gases to increase its' efficiency.
- Desaggregation – (also Bill Desaggregation) The evaluation of energy bills to determine which portions of the bills are due to which energy loads on the site.
- Displacement Cooling – Pumping low velocity, not-too-cold, cool air into a building at floor level and exhausting the rising warm air up high.
- District Heating and Cooling – A regional heating and cooling system that uses centralized boilers and chillers to generate hot water (or steam) and chilled water.

The water is then circulated around the region, and buildings tap into the loop with heat exchangers and subloops for local heating, cooling and hot water.

- Energy Efficiency – A relative measure of the amount of energy it takes to perform a task. A high-efficiency appliance will perform the same task as a standard appliance for less energy.
- Energy Star - An energy efficiency rating system for products and buildings. Energy Star windows have an SHGC and U-Value below .35. Energy Star houses perform better than 15% above California Energy Efficiency Standards (Title 24). Appliances are also rated based on their energy consumption.
- Evaporative Cooler – A cooling device that evaporates water over a media to cool air that is passing through the media. The effectiveness of an evaporative cooler is a function of the outdoor air temperature and relative humidity. Evaporative coolers are normally 100% fresh air units, meaning that all air delivered is drawn from the outdoors and pressurizes the building making it necessary to have relief.
- Evaporator Coil (or A-Coil) – Portion of an AC system that sits in the air stream of the cooling system and cools the air. Similar in appearance to a car radiator, but has refrigerant in it rather than water. Usually attached to the outlet of the furnace before the ducts branch off.
- Hydronic – Heating (or cooling) system that uses water or another liquid as the energy transport medium, rather than air. A hydronic radiant floor system means there are tubes in the floor that hot and cool water flows through. A hydronic coil sits in the air stream of the conditioning system and heats or cools the air depending on the temperature of the water flowing through it.
- KiloWatt Hours – (kWh) A measure of energy consumed over a period of time. If a 100W light bulb is left on for 10 hours, it will consume 1000Wh or 1kWh.
- LEED – Acronym for Leadership in Energy and Environmental Design. LEED NC (New construction) is a voluntary rating system developed by the US Green Building Council.
- Low E – A coating system for windows and skylights that blocks some of the heat components of sunlight while letting visible light through.
- Luminaire – Light fixture, including the trough, ballast and bulbs.
- Net Metering – The practice of measuring energy in and out of a property, then sending one bill for the whole year. This allows PV users to build up a negative balance in the summer, then use it up in the winter.
- Passive Solar – Window and overhang/shading orientation designed to maximize the solar thermal gain in a building in the winter, but shade the windows in the summer. Uses the seasonal difference in the angle of the sun.
- Payback – Amount of time it takes to recover the cost of an investment due to the benefits of that investment. Usually use “Simple Payback”, which = cost/annual savings (ie.: an \$1800 solar hot water heater that saves \$300 per year has a simple payback of 6 years). Improvements for comfort and convenience have no payback if they have no quantifiable cost savings.
- Photovoltaics (PV) - Panels that generate electric energy using the sun.
- Relative Humidity – The amount of moisture in the air relative to the total amount air of that temperature could hold. At 100%, it starts raining or gets foggy.
- R-Value - Resistance to heat conduction of a building material. Used primarily for insulation materials. Inverse of U-Value.

- SHGC – Solar Heat Gain Coefficient. The amount (in %) of the thermal component of the sunlight that hits a window that will be let through.
- Solar DHW or HW – Solar water heaters use the sun to heat water for domestic use or for space heating.
- SunScreen – An exterior screen (similar in appearance to normal window screens) that blocks 75 to 90% of the invisible, heating rays of the sun.
- Thermal Mass – The mass of the internal components of a building (sheetrock, flooring, furniture, etc) that has the capability to store thermal energy. The more dense a material, the higher the mass. Thermal mass helps to stabilize the indoor temperatures of a building.
- Thermal Storage - The practice of chilling or freezing a mass of water over a long period of time to serve as a cooling reservoir during hot weather, or heating a mass of water over a period of time to satisfy heating loads. Mainly for buildings with periodic loads (once a week) and big demand charges.
- U-Value – Thermal conductivity of a building material. Used for Window and door rating as well as whole wall assemblies. Inverse of R-Value.
- Watts – (W) A measure of power, such as that needed to operate an appliance. A light bulb needs between 15 and 300W. A standard residential air conditioner needs 2000 to 5000W
- Zero Energy – A building or property status that indicates the net amount of electric or total energy consumed for a year is equal to zero. See “Net Metering”.

2.2 Fundamentals of Heating and Cooling Loads

2.2.1 Fundamentals of Heat Transfer

Heat moves from hot to cold. There is no such thing as “cold”, there is only a lack of heat. “Cold” is an adjective we use to describe things which have a low amount of heat. In the summer time the heat is trying to move from the warmer outside to the cooler inside, and in the winter the heat tries to move from the warmer indoors to the cooler outdoors. It is this transfer of heat that necessitates heating and cooling equipment. Heat transfer is categorized into four mechanisms:

Table 1- Mechanisms of Heat Transfer

Mechanism	Description	Examples
Conduction	Movement of heat through solid objects.	Heat traveling up a steel rod that has one end in the fire.
Natural Convection	Transfer of heat from solid objects to surrounding fluids under still conditions.	A hot object cooling in still, cool air.
Forced Convection	Transfer of heat from solid objects to fluids moving past.	A hot object with a fan blowing air over it to cool it.
Radiation	Transfer of heat from a hotter object to a cooler object across a distance regardless of fluids or space in between.	Warming hands or back at a fireplace or campfire. Sun heating the inside of a car through the windows.

The central California valley is a cooling dominated climate, meaning that the standard building should use more energy for cooling than heating, assuming both systems are present. Heating and cooling systems are needed to combat heating and cooling loads that are created by the seasonal extremes. The following sections are a discussion of these heating and cooling loads.

2.2.2 Heating loads

In the winter time, heat leaves a building in several ways. The total amount of heat that leaves must be replaced to maintain the indoor temperature at a comfortable level. The following are examples of heating loads:

- Heat conducts through the walls and roof from the indoors to the outdoors.
- Warm bodies and surfaces inside a house radiate heat to the cold outdoors through uncovered windows.
- Cold air blows in through cracks around windows and doors, forcing warm air out other openings (infiltration).
- Fresh, cold air is brought in from outside to satisfy ventilation needs.
- Heat is conducted out of the slab into the cold soil.

These heating loads can be minimized through choosing high-quality windows, high R-value wall assemblies, and weatherstripping doors and windows.

2.2.3 Cooling loads

In hot weather, heat enters a building through the same mechanisms that it leaves in the winter, only in reverse. If it is sufficiently hot outside, and the sun is shining on the building, the heat entering the occupied space must be removed by mechanical means. The following are examples of cooling loads:

- Heat conducts in through the walls, roof and windows from outdoors to indoors.
- Direct sunlight enters through a window or skylight and hits floor, furniture, and walls inside of house.
- Hot air blows in through cracks around windows and doors, forcing cool air out other openings.
- Fresh, hot air is brought in from outside to satisfy ventilation needs.

Cooling loads are also minimized by the envelope measures mentioned under heating loads. A high quality envelope is the first step in minimizing the space conditioning energy use of a building.

2.3 Discussion of Building Systems

The building systems that affect comfort and related energy use are lighting, the envelope of the building, the heating ventilation and air conditioning (HVAC) system, the domestic hot water (DHW) system and on-site renewable energy generation systems. The envelope of the building determines how much heat is allowed to enter or leave the

occupied space, and the HVAC system introduces or removes heat to achieve the conditioning goals of the occupants. The DHW system heats and distributes hot water, and the on-site renewables endeavor to generate the energy for the site, reducing the need for purchased energy. The following is a discussion of some of the options for these systems and how they work.

2.3.1 Lighting and Daylighting

Lighting can make up a major portion of a building's energy use. The electric use of a building can be 50% or more of the total energy use. In recognition of this fact, many building codes, energy codes, and points rating systems (LEED, Energy Star) are giving credit for using efficient lighting and daylighting systems. Table 2 outlines some technologies for energy efficient lighting.

Table 2 - A partial list of available lighting technologies.

Technology	Description
Incandescent Lighting	A resistive filament is heated by running electricity through it, which makes it glow intensely. These are the standard, most common light bulbs that have been in use for close to a century.
Flourescent Lighting	A glass tube filled with a fluorescent gas is excited with an electric current that makes the gas glow. Fluorescent lights have been used for several decades, but the older T12 (1.5") light fixtures are low output and have magnetic ballasts that consume energy. Modern T5 (5/8") and T8 (1") tubes use electric ballasts and use a fraction of the energy of a T12.
Compact Florescent	A miniature version of the tube fluorescents with a built-in electric ballast. These are commonly used to replace incandescent bulbs due to their much lower energy consumption.
LEDs	LEDs (Light Emitting Diodes) are very small electronic components that light up when energized. They are commonly used to light up buttons on cell phones, dials on dashboards, etc, and for general lighting when grouped in bulbs for tract lighting, bike lights, etc. These lights use very, very little energy, but also are low output. LEDs are currently for specialty lighting , but they are under constant development.
Simple Lighting Controls	Motion sensors, photocells and timed switches can be used to minimize wasted energy from lights being left on.
Advanced Lighting Controls	Lighting control systems are available that can guard against the wasted energy of lights being left on, or operating outdoor lighting during the daytime.
Daylighting Strategies	Daylighting is the use of natural light through windows and skylights in place of electric light. Daylighting controls use light sensors to determine if enough natural light is entering the space

A first step in most lighting retrofits is to switch out all of the old style fluorescent tubes and ballasts, and to delamp the fixtures from four to two tubes. The modern tubes and ballasts have superior energy efficiency and light output to the old T12 fixtures.

Many other lighting technologies are available or under development. A lighting specialist should be consulted when planning a lighting retrofit to ensure an optimum system.

2.3.2 Building Envelope

The building envelope consists of walls, ceiling/roofs, floors, doors, windows, and skylights. The purpose of the envelope is to keep the elements out and to help maintain the comfort level of the space. The following is a discussion of the various parts of an envelope and how to select the best technologies and techniques to achieve the desired comfort and energy efficiency goals.

2.3.2.1 Wall and Ceiling/Roof Insulation

The majority of homes are built with stick framing (2x4 or 2x6 douglas fir). Small commercial buildings are usually built light steel framing or wood framing. As buildings get larger, concrete and medium to heavy steel construction are more typical. Insulation is usually installed between the framing members to prevent the air from moving around in these cavities. The insulative value of a wall or ceiling/roof assembly is a combination of the insulative values of all the building materials. Framing members made of highly thermal conductive materials, like steel and concrete, can conduct around insulated spaces if the member is exposed to both the indoor, conditioned space, and outdoors. Thermal “short-circuits” of this type degrade the insulative value of a wall assembly. Ideally, a continuous insulating layer (like spray or board foam) is added inside or outside of the framing members to prevent any thermal bypass and increase the overall insulative value of the assembly. A good wall assembly will have an R-value of 15 to 22+. A good ceiling/roof assembly will have an R-value of 19 to 49. Buildings that are continuously occupied will benefit more from high levels of insulation.

2.3.2.2 Interior Thermal Mass

The quantity and density of the interior thermal mass of a building determines the stability of the indoor temperatures. High density materials like concrete and steel (and sheetrock and wood, to a lesser extent) can store a large amount of heat for a long time. Heavy, dense materials can then give up heat or absorb heat as the indoor air temperature changes, greatly slowing the degradation of indoor conditions caused by exterior loads. An example would be a passive solar building with large amounts of concrete inside the insulated envelope. During the day the sun shines in though the windows and heats the thermal mass. At night the mass releases its heat to the house. Buildings that are occupied on a regular basis (residences, businesses, educational facilities) can greatly benefit from high interior thermal mass. Buildings that are irregularly occupied should

not have a lot of thermal mass because it takes a very long time to change the indoor conditions, and therefore may need to be conditioned around the clock at a high energy cost.

2.3.2.3 *Absorptivity, Emissivity and Reflectivity of Building Materials*

The absorptivity and emissivity of a surface determines the amount of radiation they can absorb, and how well they will emit stored heat to cooler surfaces. Reflectivity is related to these characteristics, in that a material with low absorptivity is highly reflective, and vice versa. Highly reflective materials are usually poor emitters. This is evident in the effectiveness of radiant barrier material now used in residential attics. This foil faced plywood stops the roof deck (with its heat collecting shingles) from radiating its heat into the rest of the attic.

The main issue with building materials is to select low absorptivity materials for surfaces exposed to the sun. Roofs are the main issue here. Dull black materials absorb heat very well, where glossy white or silver materials are poor absorbers, or good reflectors. The final coating for a roof in a cooling dominated climate should be a bright reflective color.

A line of paint products has been developed that allow buildings to have surfaces of any color they want with less thermal consequences. These “Cool Colors” are engineered pigments that reflect away the 50% of the solar heat that is in the invisible near-infrared realm (see Figure 1).

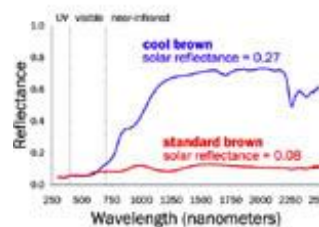


Figure 1- Comparison of the reflectance of a standard pigment to a Cool pigment.

2.3.2.4 *Windows and Skylights*

Windows and skylights offer natural lighting and views, but they do increase the energy consumption of a building for several reasons. First, even high efficiency windows have a much lower R-value than most solid walls (R-4 versus R13+). The more glass a building has, the more readily heat will transfer in and out of the building. This effect can be attenuated with insulated shutters on the inside or outside of the windows.

The second way that windows impact the comfort level and energy use of a building is by allowing heat to enter or leave the space via radiation. Modern windows are engineered to limit the amount of solar heat that is allowed through them, and they are rated with a

Solar Heat Gain Coefficient (SHGC) to allow comparison. The lower the SHGC number, the less heat the windows let through. The SHGC value of a window can be increased by adding an external solar shade screen.

2.3.2.5 *Slabs on Grade*

A raised floor is insulated and evaluated the same as a roof or wall in section 2.3.2.1. However, buildings that are built on a concrete slab that is poured directly on the ground face a different set of heat transfer issues. The soil that the slab is sitting in and on operates on a different set of principles than the air surrounding the building. Soil temperatures at the surface largely follow the adjacent outdoor air, but as the soil gets deeper the temperatures stabilize, and soon (maybe 20' down) the temperatures stay the same year round. A building slab sits in the first few feet of the soil, where the temperatures are most volatile. In colder climates the entire slab can draw heat out of the building, but in warmer climates usually only the slab edges are considered a problem. The cold soil conducts the heat out of the edges of the concrete slab, increasing the heating load and the energy consumption. In California, the importance of slab-edge insulation has been recognized, and buildings using in-floor radiant heating are required to have a certain amount. Under-slab insulation is actually discouraged in California since a ground-linked slab is actually an asset in a cooling dominated climate, drawing heat out of the building during the cooling season, thereby lowering the cooling load.

2.3.3 HVAC

HVAC systems provide heating, ventilation and air conditioning. These systems consist of a heating source, a cooling source, a source for ventilation air and a distribution system. The following subsections discuss the options for these systems.

2.3.3.1 *Options for Heating and Cooling Sources*

The distribution methods discussed in section 2.3.3.2.1 rely on a supply of heated or cooled air or liquid. This section is a discussion of how the air gets heated or cooled. Many options exist for creating sources of heated and cooled transfer medium, but the following discussion will focus on the most recommended methods.

2.3.3.1.1 *Heating-Only Systems*

The following are some of the available high efficiency systems available for space heating:

- Condensing Gas Furnaces – Furnaces are used to heat air for distribution by one of the methods outlined in section 2.3.3.2.1 below. These are the most efficient furnaces available. These furnaces achieve better than 94% efficiency by harvesting heat from the exhaust gasses of furnace burners. Normal furnaces can get little better than 80% efficiency.

- Condensing Boiler – Boilers heat water for space heating and for domestic hot water. Condensing boilers achieve high efficiencies by the same method as condensing furnaces do.

2.3.3.1.2 Cooling only systems

The following are some of the available high efficiency systems available for space cooling:

- High Efficiency Air Conditioners – Air conditioners pump heat out of an airstream for distribution by one of the methods outlined in below in section 2.3.3.2.1. Air conditioners are usually split systems with the evaporator located at the furnace and the condenser unit located outside. High efficiency condenser units have been developed that perform much better than anything sold more than a decade ago. One problem with any traditional air conditioning system, though, is that it must pump heat out of the cooler indoor air, and waste it to the warmer outdoor air. As the outdoor temperatures rise, the more the system is needed and the harder the system must work to move the heat. Since the system must now use more energy to perform the same task, the efficiency drops dramatically.
- Electric Chiller – Chillers are like air conditioners, but pump heat out of a liquid to create a chilled water source.
- Evaporative Coolers – Evaporative coolers use wetted media to cool air with the latent heat of vaporization. The most simple of these systems are the swamp coolers that have been used for decades. More advanced units exist now that use indirect and multi-stage evaporative cooling devices to maximize the effectiveness of this equipment. One downside to these technologies is that they use a lot of water, which can get expensive in areas where water is metered.
- Water Cooled (evaporative) AC – This technology uses a high efficiency air conditioner condenser unit, and uses evaporative cooling technologies to cool the air used to cool the condenser. This maintains the efficiency of the system, even when the outdoor air temperatures rise. Again, these systems consume water, and therefore have other “green” consequences.
- Cooling Towers – A cooling tower uses evaporative cooling to remove heat from a water volume while giving up some of that volume to evaporation. These towers may be used to cool water for underfloor cooling, or for condenser cooling.

2.3.3.1.3 Systems that both Heat and Cool

The following systems have the ability to efficiently deliver both heating and cooling:

- Air side Heat Pump – This is similar to an air conditioner, except that it is reversible and can heat in the winter. These systems, while they offer the benefit of being all electric, and therefore would help towards a Zero Energy Campus,

they are rather inefficient in the winter. They are also limited by the fact that they are air conditioning units, meaning that they don't have the flexibility that liquid has to serve the whole campus with a single unit.

- Ground Source Heat Pump – A ground source heat pump uses 200 to 300' deep wells to access the thermal sink of the soil at those depths. Water is circulated through pipes to transfer the heat to and from the soil. The water is then circulated up to a heat pump that acts like a chiller or air conditioner, heating or cooling air or water as is needed. Ground source heat pump systems are far more efficient than the air source systems, but are expensive to install because of the drilling of the wells.

2.3.3.2 Options for Heating and Cooling Distribution

The two main options for the distribution of heating or cooling energy are by forced air and circulated liquid. The air or liquid is heated or cooled then transported to the locations where the conditioning is needed. The following subsections are a discussion of these options:

2.3.3.2.1 Forced Air Options

Forced air systems are the most common heating and cooling distribution systems in homes and commercial buildings today. They also create and/or worsen common problems with space conditioning. The main reason is that hot air rises, and most forced air systems deliver relatively hot air to the space. The air then will rise immediately, warming the room from the top down, sometimes never heating the floor. These systems work a bit better with cooling, since the cool air will drop to the floor and the warm air will rise to be drawn off by the return of the system. Some optimized systems do exist that use small temperature changes, natural convection, and low airflow rates. These will be discussed under Displacement Systems.

- Ducted system – a ducted system uses ducts to distribute the conditioned air throughout the building. Standard ducted systems rely on high velocity air to keep the air mixed in the space being conditioned and to minimize stratification. An ideal system would deliver heat near the floor, horizontally, and deliver cooled air up high, with returns at the same elevations (high or low) as the supplies, but at the opposite end of the building.
- Displacement Systems – Displacement cooling systems come in several configurations. There are underfloor systems which rely on a large underfloor plenum to deliver air at a temperature very close to the desired air temperature, at a low velocity. The air is introduced through openings in the floor and drawn off by a return at the top of the room. The air moving upwards past the occupants transfers heat from them and carries it up to the return along with moisture and any airborne germs that might be going around. A sidewall displacement system

uses low velocity sidewall diffusers to achieve the same goals. These systems are not as effective as the underfloor systems, but are much easier to retrofit into a building. These systems are considered far superior to conventional ducted systems.

2.3.3.2.2 *Water (or other liquid)*

Water (or liquid) systems have been used for a long time, especially on large campuses where district heating and cooling are used. The use of the technologies listed below are gaining popularity as the energy efficiency of building systems become more and more important. Water has superior thermal transport qualities to air, and makes for more flexible distribution systems. The following is a partial list of liquid transport heating and cooling systems.

- Radiant Floors – Hydronic radiant floor systems distribute heated (and sometimes cooled) liquid through tubing imbedded in the floor of a building and conditioning the mass of the floor. The floor in turn radiates (or absorbs) heat from the surrounding walls, furniture and ceiling, creating a comfortable surrounding environment. Hydronic radiant floor systems tend to create a comfort profile (warm-feet/cool-head in heating mode, cool-feet/warm-head in cooling mode) that is optimum for human occupancy. Great care must be taken if a radiant floor system is to be used for cooling. Even with the evolution of radiant floor controls, the danger of cooling a floor down below the dew point of the room can be disastrous. This would cause condensation to form on the floor which could destroy flooring and/or cause mold problems in carpeting. Despite these dangers, this method is highly recommended.
- Hydronic coils – Hydronic coils are similar to car radiators. Hot or cold water is circulated through them, then air is blown across the coil to condition the air. The air may then be distributed by one of the methods outlined in the “Ducted” section above. Keep in mind that piping water around a building is usually easier than ducting air, and the hydronic coils can be distributed throughout the building, perhaps right next to the areas where the conditioning is needed. This sort of ductless system can be designed to be very efficient. Hydronic coils can also be used to condition ventilation air before it reaches the occupied space.
- Hydronic baseboards – Hydronic baseboards are like the electric baseboards that have been used on the East Coast and in the Midwest for a long time. The difference is that high temperature water is passed through a pipe in the baseboard and fins distribute the heat to the surrounding air. The method is good for inconsistently occupied spaces because it heats the space rather quickly, but fans must be used in tall spaces to mix down the warm air. Cooling should not be used with a system like this due to the condensation that may form on the tubing, and also the fact that the baseboard sits close to the floor where the cool air would collect.
- Chilled Beams – Chilled beams are heating and cooling devices that circulate hot or cold water through horizontal heat exchangers placed around a space, usually

in the ceiling. They use either the rising or falling of natural convection, or induced flow from passing ventilation air to heat the air that is already in the room. Because these systems use little or no forced air, they are very energy efficient.

2.3.3.2.3 Zoning

Zoning allows a system to condition a portion of a building when the whole building is not being used. Naturally, the more zoning that is used, the less unnecessary energy is used. A good example of this is the zoned AC system that serves the offices and the library in the Main Building. An ideal system will use zoning as much as possible. Radiant floor systems offer the most flexibility for zoning.

2.3.3.3 Ventilation Air

Though non-residential buildings require that ventilation air is supplied during occupied hours to ensure good indoor air quality, the introduction of outside air is an additional load on the heating or cooling system. Because ventilation air increases energy use, it should be minimized when possible. Ventilation air can be delivered by one of two methods: Constant ventilation or demand ventilation.

With a constant ventilation system a prescribed amount of air is supplied to the space anytime the space is occupied. Usually the amount of required air is determined by multiplying the maximum occupancy of the space by a set value (15cfm/occupant for most building types). The problem with this method is that regardless of the number of occupants, the airflow will always be set for the maximum.

Demand ventilation uses CO₂ sensors to trigger fresh air ventilation, ensuring that an optimum airflow rate. This method should be used whenever possible, as it minimizes energy use.

2.3.4 Domestic Hot Water

2.3.4.1 Hot Water Sources

There are many sources for domestic hot water for sinks, showers and dishwashers. Some options include:

Table 3- A partial list of sources for domestic hot water.

Hot Water Source	Description
Storage or Tank	This is the most common type of water heater. It consists of a tank with a gas burner or an electric heating element. The tank is usually maintained at the desired temperature 24/7.
Boiler/Storage Combination	Some new products on the market combine a small, high-efficiency boiler with a high tech, well insulated tank. A solar model is available

	that keeps the water in the top portion of the tank with the adjacent boiler, then heats the bottom portion of the tank with a solar heat exchanger. This allows the solar system to maintain the tank at temperature, something a normal 2-tank solar system cannot do.
Tankless or Instantaneous	A tankless water heater is a compact appliance about the size of a suitcase that contains a bank of variable, high output burners and a high performance heat exchanger. This combination allows water to be heated immediately from 55° to between 120 and 180°. A condensing version is available.
Heat Pump	A heat pump water heater pumps heat from the ground or air to a volume of water to be stored for domestic use.
Solar	Water is circulated through solar collectors and stored in a tank. This is usually a “pre-heating” strategy, since hot water is sometimes needed when the sun is not available.
Indirect	An indirect water heater uses an external heat source or reservoir, such as a space heating storage water tank, to heat domestic water with a heat exchanger.
Waste Heat Recovery	Cooling appliances (refrigerators, air conditioners, heat pumps) waste heat to the air or the ground, and hot water is frequently drained to the sewer while it is still hot. Waste heat recovery involves harvesting as much heat from these waste streams as possible.

In general, tank water heaters are maintained at the desired operating temperature 24/7. Since the tank is always kept at a high temperature, the heat is always trying to move to the cooler surroundings. For this reason, it is very important to ensure that the tank is well insulated to minimize these storage losses.

Another approach to tank heaters is to put them on a timed schedule so that they are only maintaining the reservoir when the building is occupied. This is very easy to do with simple electric water heaters, but is more difficult with standard gas tank heaters since they usually have self contained controls. Modern, high-efficiency gas tank water heaters sometimes offer better controllability.

2.3.4.2 Hot Water Distribution

In an ideal world, all fixtures requiring hot water would be clustered to a central location in a building so that the hot water would not need to travel far and the wait for hot water would be short. Unfortunately, buildings are not normally designed this way, and retrofits almost always involve sending hot water long distances. Long hot water runs create several problems:

- Inconvenient long waits for hot water. When long pipes are used to supply a fixture, the water can take long enough to inconvenience users. Often the hot water never arrives since the user turns the fixture off before it comes. The energy used to heat the water that is drawn into the pipe is wasted.
- Wasted water from waiting for hot water to arrive. The California Energy Commission ran a study that concluded that wasted water equals wasted energy.

- Decaying of hot water in the long pipes. Hot water left in long pipes after a draw will eventually lose its heat and equalize to the surrounding temperatures. This is wasted energy.

Some solutions to the problems with domestic hot water systems are:

- Short pipe runs – The ideal solution to distribution problems is to minimize the length of the runs to the fixtures. This is seldom an option with an existing building.
- Recirc pumps – To attenuate the inconvenience of long waits for hot water, and the wasted energy of wasted water, recirculation pumps may be used to ensure that hot water is close to the fixture when it is needed. Recirculation pumps may be controlled by an aquastat and timer
- Well insulated pipes – All hot water pipes should be insulated from hot water source to fixtures to minimize energy loss.
- Small diameter pipes – Small diameter pipes ensure that a minimum volume of cold water must be flushed from the pipes before the hot water arrives.
- Multiple water heaters - On a large campus, or in a large building, sometimes the fixtures can be so far apart that multiple water heaters are needed to minimize the length of the hot water runs.

2.3.5 On-Site Renewable Energy Generation

Some of the current choices for sustainable on-site energy generation are Passive Solar design, Photovoltaics (PV), solar hot water, and windpower. The following is a brief survey of the technologies in this partial list:

Passive Solar Design – The practice of designing and orienting a building to use shading and windows to allow solar gains in the winter, and block out solar gains in the summer. Considerations are given to interior thermal mass to ensure that the heated or cooled mass can coast the building through extreme weather.

Photovoltaics – PV panels convert sunlight into electricity. There are many technologies available and many under development at this time. Incentives, such as rebates and tax write-offs are available to assist in the purchase of these systems. Net metering would be required to keep a PV array a manageable size.

Solar Hot Water – Solar water heating systems are described in Table 3 in section 2.3.4.1.

Wind Power – Although a less common option, wind power is can be an excellent compliment to solar power due to its power profile. Solar power peaks daily in the afternoon as long as the sun is shining. Wind power peaks when the wind is blowing, often when the sun is not shining. Wind generators are available in a variety of sizes.

3 Site Description

The UUSS campus is located on Sierra Blvd, east of Howe Avenue in Sacramento, CA. The 6.4 acre campus (see Figure 2) contains two buildings; The Main Building consisting

of the Main Hall, library, kitchen and offices, and the Classrooms complex, consisting of offices, meeting rooms, classrooms and other flexible spaces in three connected buildings. The Main Hall and leftmost classroom building (building 1) were built in 1960, and the other two classroom buildings were added in 1965.

The property has a large parking area and there are trees on much of the property, shading some of the land and buildings. This will be discussed more when solar is discussed. Figure 1 shows an aerial view of the campus. See audit results for a description of each of the buildings and a discussion of the energy usage issues.



Figure 2- Aerial View of UUSS Campus.

4 Audit results

A cursory inspection was performed on each of the buildings on the property focusing on the insulation qualities of the buildings and the appliances and equipment that consume energy. The following are the findings from the bill study and walk-through.

4.1 Campus Energy Use

The audit began with a review of the energy bills for the campus for the last three years. The monthly energy consumption data was entered into a spreadsheet and reviewed for usage patterns and disaggregation. A plot of the data collected can be seen below in Figure 3:

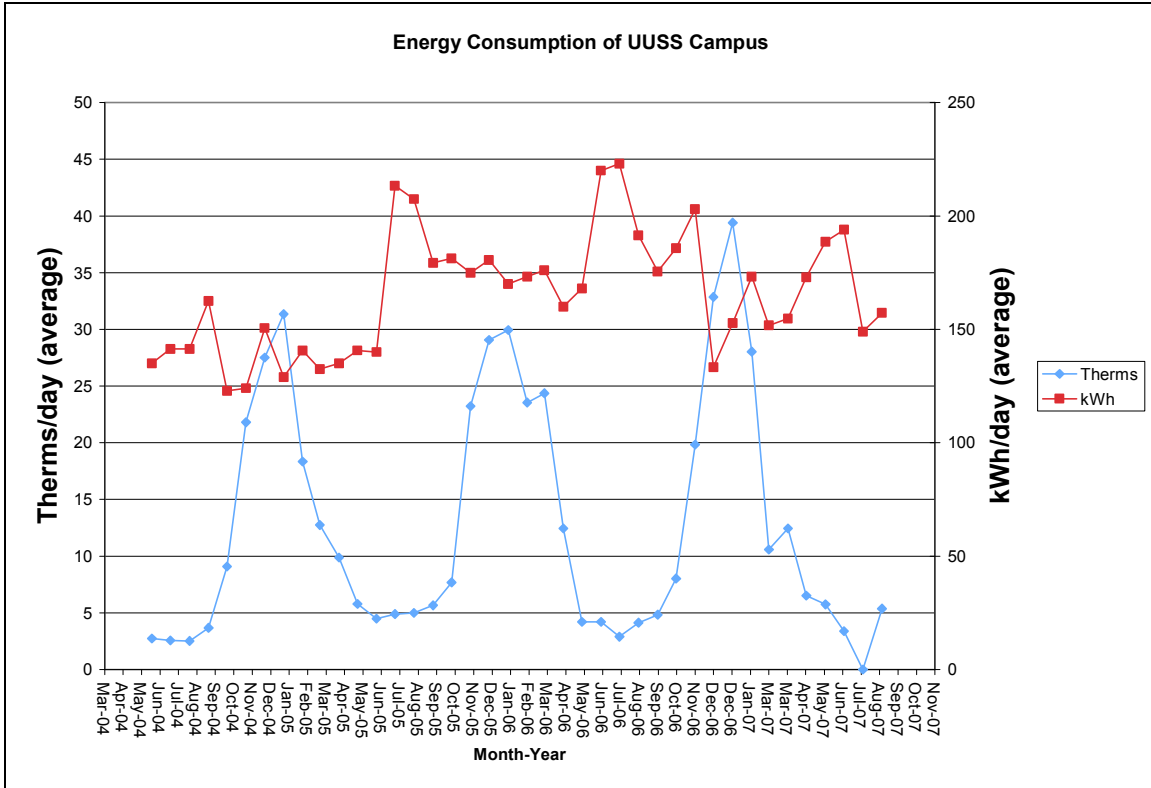


Figure 3- Chart showing gas and electric use for the UUSS campus.

A rough disaggregation shows the following conclusions:

- Gas use is very highly dependent on space heating requirements. Very little water heating is required despite the storage losses of the existing heater.
- The base daily use for the Campus varies from 3 to 5 Therms/day.
- Baseline use was ~138 kWh/day for June 04 to June 05, but the baseline since then is closer to 170 kWh/day. This baseline may go back down now that the kitchen is no longer rented out.
- The summer of 2005 had a cooling spike to 210kWh/day. This represents a 38% increase of the 04/05 baseline. Depending on the cause of the change in baseline, part of the increase in energy use could be due to non-cooling causes. The 2006 spike is similar to the 2005 at 222 kWh/day. Assuming that the higher baseline is accurate, cooling consumption represents from 19 to 23% increase in energy use during the summer.

UUSS has been spending an average of ~\$14k for the last 3 fiscal years. The EPA Energy Use Index for Religious Worship buildings in this climate zone averages ~\$8.5k for buildings of the same size. No one in the industry will commit to a hard estimate of what will happen to energy prices over the next few years, but it is a safe bet that prices will generally go up. Estimates range from 20% to 70%. Table 4 shows what the average annual energy cost (about 50/50 between gas and electric) for the campus from the last three years (labeled “historical”) along with what the annual energy cost would be for various increases in energy prices. Assuming the energy

prices rise 30% on average over the next 2 years, we can expect the total cost to top \$18,000 per year by the end of 2010. This value will likely continue to rise according to most experts.

Table 4 - Annual energy cost projections for USS campus for various energy price increases.

		Annual Energy Cost
	historical	\$ 13,958
% Increase in Energy Prices	10%	\$ 15,354
	20%	\$ 16,749
	30%	\$ 18,145
	40%	\$ 19,541
	50%	\$ 20,937
	60%	\$ 22,333
	70%	\$ 23,728

4.2 Main Building

4.2.1 Description:

The Main Building is around 10,000 sqft, and contains the Main Hall, Stage and Backstage, Lounge, two Kitchens, Offices and the Adult Library. The floor plan consists of two connected hexagons. The larger hexagon contains the Main Hall, which is the gathering place for the congregation, with a stage at one end and some partitioned areas to each side. One partitioned area contains a small lobby and two bathrooms, while the other area is for storage. The smaller hexagon contains a central social space with a sliding partition wall to separate it from the Main Hall, a series of office spaces, two kitchens and the Adult Library. A rear loading area has been closed in to support the large kitchen with storage. The large kitchen contains commercial kitchen equipment and was rented out to a catering company from late 2004 till August of 2007. The smaller kitchen supports coffee and food preparation for the congregation, but does not contain any stoves or ovens.

The Main Hall has a vaulted, exposed beam ceiling, while the other spaces in the building have flat ceilings below shallow or flat roofs (Figure 4).



Figure 4- Flat roof on office/kitchen/library portion of Main Building. Dome roof over Main Hall.

4.2.2 Energy Issues:

4.2.2.1 Building Envelope

The walls of the Main Building are formed, tilt-up concrete with hexagonal single pane windows (see Figure 5). Banks of wood-framed, single-pane rectangular windows with frosted patterns are used for entryways to the Main Hall on the east and west, the side entrance to the lounge, and the back of the offices (see Figure 6). The wooden frames around the windows are thin (less than 1.5 inches), but are probably the most insulating materials in the walls. The doors in these window-walls are not weatherproofed and some have sagged and fit poorly up to the thresholds.



Figure 5 – Concrete tilt-up wall with window perforations.



Figure 6 - Window walls with glass doors.

The ceiling in the Main Hall is dome-shaped and about 20' tall at the peak (see figures 7 and 8). It has a hexagonal footprint and exposed beam roof with a variable pitch. The roof deck appears to be of tongue and groove or lap board redwood, probably no more than 1.5" thick, with a rolled asphalt roofing product on top. The roof surface is painted white, but is older and is starting to degrade in places.



Figure 7 - Domed ceiling in Main Hall

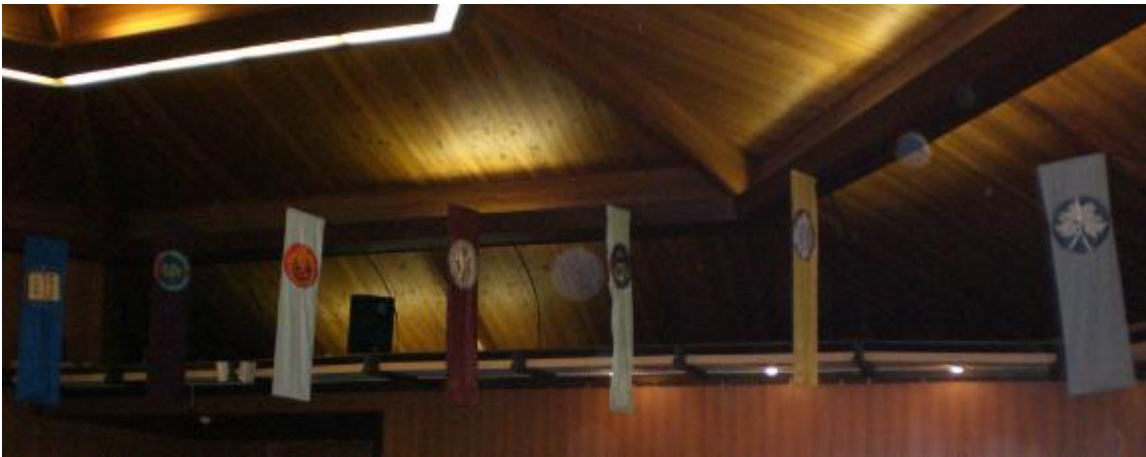


Figure 8- The edge of the domed roof of the Main Hall.

4.2.2.2 HVAC

The Main Hall uses a lot of energy when heating or cooling due to the envelope characteristics mentioned above. The heating system is a commercial, forced-air, gas furnace with under-floor ducts and permanent grilles around the building perimeter. Some grilles are blocked off in the lounge, and there are damaged grilles in the storage rooms on the west side of the building (see figures 9 through 14). There is no cooling system connected to the central ducting. The furnaces and associated controls were installed when the building was completed in 1960, which makes them almost 50 years-old like the rest of the building. Despite the age of the ducts, heating equipment and

thermostat, the feedback sensors and fan motor are relatively new, and the fan motor is rated for continuous operation. The damper for fresh air is adjusted shut for this unit, but with a building of this age (very leaky) it is probably not a problem. Unless there are problems with stuffiness and lack of fresh air, this damper can be left as is. Fresh air will increase the heating loads. The recent maintenance indicates that the system is regularly maintained and repaired, and is most likely that the system is at maximum possible performance for one of that age.



Figure 9- Perimeter heating vents.



Figure 10 – Damaged vent in table storage area.



Figure 11 – Typical perimeter vent in office space.



Figure 12 – Supply ducts for furnace with analog sensors and controls.



Figure 13 – Blocked off vent in Lounge area.



Figure 14 – Thermostat for large heating system in Main Building.

Some small evaporative coolers have been installed to supply cooled air to the Main Hall and Kitchen via a plenum under the stage (see figure 15). These coolers are aspen pad type units which typically perform at lower evaporative efficiencies (50-70%) compared to the more advanced cellulose units (up to 95%) on the market. But efficiency is less of an issue than the fact that the units are undersized for the worship space and kitchen that they were installed to serve. They were purchased to offer some cooling to the congregants and the cooks from the catering business that leased the kitchen on weekdays, but they were not intended to be a permanent solution for cooling the space.



Figure 15 –Evaporative Coolers for Main Hall.

A cooling system is installed in the electrical/mechanical/storage space near the offices, which serves both the offices and the library (figure 16 and 17). This system is 5 to 6 years old, and the condenser unit is located on the roof. The air handler is mounted on a shelf in the upflow orientation and draws the return air through the bottom of the shelf. A filter is mounted below the shelf with a tub below that to catch any condensate that might fall from the evaporator coil. This system is zoned between the offices and the library, with separate thermostats and transfer grilles to equalize pressures between the rooms.



Figure 16 - Air conditioning unit for offices and library.



Figure 17- Filter and tub at intake of AC unit.

The basement stairs are accessed from the loading dock/kitchen storage space that is vented to the outside for the HVAC fresh ventilation air. The bathrooms near the offices vent to this space.



Figure 18 – Exhaust fan from bathroom to loading bay.



Figure 19 – Openings for fresh air for main furnace and relief for bathroom ventilation fans.

4.2.2.3 Lighting

The lighting in the Main Hall is currently undergoing retrofits for efficacy and efficiency. Other portions of this building have outdated fluorescent luminaires and old globe style hanging fixtures and flood fixtures. Most of the bulbs in these fixtures have been replaced with compact fluorescent bulbs to save energy.

4.2.2.4 Domestic Hot Water

The hot water for the Main Hall is supplied by an insulated storage gas water heater that is located in the basement. This heater is old but in very good condition. As mentioned above, the baseline hot water load is very low.

4.2.2.5 Kitchen Appliances

The larger kitchen contains commercial cooking, refrigeration and dishwashing equipment. This equipment was in heavy use when the space was rented to the catering company for the last 3 years. This area is used less now, and one of the refrigeration units no longer works. The smaller kitchen contains an old commercial style small refrigerator that is kept unplugged most of the time and a modern, energy efficient chest freezer (2005) that is left plugged in and used regularly. This space also contains two commercial coffee makers and a microwave oven.

4.3 Classroom Buildings

4.3.1 Description:

There are three classroom buildings to the East of the Main Building. Each building is about 1500 sqft, designed around a square main room with smaller rectangular ante-rooms. Building 1 contains some offices, bathrooms, and a meeting room that is currently undergoing an upgrade. Building 1 and 2 are connected by an enclosed storage space that used to be a walkway Buildings 2 and 3 contain most of the classrooms.

4.3.2 Energy Issues:

4.3.2.1 Envelope

Building 1 has similar concrete walls and window-walls to the Main Building. Buildings 2 and 3 are stick frame buildings with aluminum framed, single-pane windows for the most part, with some concrete walls with hexagonal windows. These buildings all have flat roofs with 1-2" of foam recently applied. There may be batt insulation between the ceiling joists, but if there is, it is little.

4.3.2.2 HVAC

Each classroom building is served by two split system FAU/AC units. The Furnace units are installed in closets to serve adjacent areas, and the condenser units are mounted on the roofs. The units are about 10 years old (except for one condenser unit on building 3 that was replaced recently). Programmable thermostats are installed nearby.

4.3.2.3 Lighting

Lighting in these buildings is supplied via square ceiling can-lights which contain CFLs or pin-type fluorescents. Some of these spaces appear to have old tube-style fluorescent lights with magnetic ballasts.

4.3.2.4 Domestic Hot Water

The restrooms in Building 1 have old, 3kW electric instantaneous water heaters on each of the sinks. A small (1.5 to 2 gallon) point-of-use electric water heater is installed in the Janitors closet in Building 3 to supply the two bathrooms there. The heater was not plugged in when the audit was performed.

4.4 Remainder of Campus

4.4.1 Trees and Shading

Much of the campus is planted with trees and bushes, both young and mature. Although the shading provided by these trees is valuable because it reduces the solar gains on the

buildings and provides shaded spaces for outdoor activities, the trees greatly limit the potential locations for solar panels. The natural beauty of the campus should be preserved, as well as the shading benefits of the trees, so any suggestions for energy efficiency retrofits will not recommend the removal of any trees. At most, some trees will need to be reshaped by minor trimming and kept to a certain height with annual maintenance. These will be minor changes.

4.4.2 Lighting of Parking Lot and Paths

The parking lot lights are high efficiency lamps that qualify for a special flat rate from the utility. Outdoor lights (under the overhangs of the Classroom buildings) were found to be on in the daytime during both visits.

5 Conclusions and Recommendations

The \$14,000 spent each year on energy for the UUSS campus is money that could be spent elsewhere, and energy that could be generated on site. It is recommended that a program be put into place to start the UUSS down the road to achieving zero energy status in the next 5 to 10 years. Assuming that energy will go up by 30% in the next decade, a zero energy campus could mean more than \$9K per year in energy savings and avoided costs for Near Zero Energy, and up to \$18K per year for a True Zero Energy strategy. There are some things that can be done at low-cost or no-cost that will help get there, but the final stretch will involve some major HVAC and building envelope retrofits and putting energy generation in place to zero out the bills. Although the initial capital costs may seem large, financial methods exist to enable the UUSS to get some of the measures at lower cost and there are rebates and tax credits in place to help reduce the costs of other measures.

5.1 Overall Strategy

The first part of the strategy would be to incorporate the low and no-cost measures immediately and to be vigilant for more savings opportunities. From observations at the site, it is apparent that many decisions regarding energy are being made with efficiency in mind, so only minor changes will be recommended. See Section 5.1.1 for low-cost and no-cost recommendations.

The second step would be to address the envelope deficiencies in these buildings. Both the main hall and Classroom Building 1 have predominantly concrete walls and window walls. The concrete walls with the hexagonal windows have a R-value of less than 1, and the window-walls are little better. Classroom buildings 2 and 3 have some concrete/hex walls, but also some stick framed walls with single pane, aluminum framed windows.

The roof on the Main Hall portion of the Main building performs at around R-2.5, and the remainder is probably not much better unless someone thought to insulate between the joists during a remodel. The Classroom buildings have had about R-10 of foam built up on the roof.

Improving the window-walls and concrete walls will likely greatly alter the appearance of the building, and so will require a lot of planning a conversation to get approval from the congregation. On the other hand this will give the congregation an opportunity to find creative ways to incorporate desired themes into the new design.

The third step would be to install new, high-efficiency HVAC equipment and/or on-site renewable energy generation. There are many options for comfort systems and renewable systems, and the choices of either will influence the other. Therefore HVAC and renewables are covered together in section 5.1.3.

5.1.1 Low-Cost and No-Cost Measures:

The following is a discussion of immediate, practical measures that can be taken with low- or no-cost. These are mostly general recommendations, so the actual savings would be difficult to estimate. But if these recommendations are followed it will help the campus minimize energy use given the current conditions of the buildings and equipment.

Program Thermostats – Program all thermostats for maximum setback in all spaces that are not regularly occupied. If a space has no set, repeating schedule, then the thermostat should be programmed to set back to 55 (heating) and 85 (cooling) for all four time steps. This ensures that if someone forgets to turn off the thermostat, the system will waste a minimum amount of energy. Continue with the policy of turning off the thermostats when leaving the rooms.

Continue to lighting retrofit – Throughout the campus it appears that efficient lighting has been used to replace incandescent bulbs as they burn out. Also, a lighting retrofit is underway for the lights in the domed ceiling of the Main Hall. These efforts should continue. Old T12 luminaires (1.5-inch tubes) with magnetic ballast should be replaced with the new T8 or T5 delamped luminaires with electronic ballast when possible.

Continue to maintain HVAC equipment – The HVAC equipment appears to receive regular maintenance. Continuing this practice until it is replaced is important for keeping the systems as efficient as possible. Ensure that all systems have a maintenance plan and have the filters replaced regularly.

Continue policy of unplugging appliances when not in use – Old refrigerators and freezers are inefficient and consume a large amount of energy when operating. Any units that are not in use should be emptied, propped open, and unplugged. This practice is in place and should continue.

Timers for electric water heaters – If any electric storage water heaters are going to be in use, install a timer to turn them off when the building is not occupied.

Install Ceiling fans – Ceiling fans can provide localized cooling (accelerated evaporation from people's skin) and mix down warm air during the heating season. However, ceiling

fans DO NOT provide cooling to a room, and should always be turned off when the room is not occupied and they are being used for cooling. It is OK to use ceiling fans in unoccupied rooms to mix the warm air down during the heating season when a room is being prepared for occupation. Also, most ceiling fans on the market have very poor efficacy (CFM/Watt) due to poor motor construction and quality control. New products have been introduced to the market that perform far better than the traditional ceiling fan. The Gossamer Wind series of fans from Hampton Bay were developed with the help of AeroVironment, the company that developed the EV1 and some ultra-efficient aircraft, and consume a fraction of the energy a standard paddle fan would. If any ceiling fans are to be added or replaced, I would recommend using a Gossamer Wind model.

Install lighting controls - Motion sensors should be used for any outdoor lighting for night use. Also, the outdoor lights on the Classroom buildings (and other places that have plenty of daylighting), should use photo-cells to turn off lights when natural levels are sufficient.

Add Shading on West facing walls and windows – Adding trellises and foliage to shade the West facing windows and walls will greatly reduce the solar heat gains in the summer. If a plant is chosen that dies back in the winter, then the helpful solar heat gains during cold weather can be harvested to reduce heating loads.

Shading on condenser units – Trellises that shade condenser units can increase the efficiency of the units while improving the aesthetics of the buildings.

5.1.2 Recommendations for Building Envelope Improvements

5.1.2.1 Recommendation for Window Walls

Determine how much of the window walls actually need to be doors and how much of that space can be framed in and insulated or decorated with fixed windows. The window walls currently extend to the top of the wall (approx 10 feet) as seen in Figure 20. It is possible to reduce the window walls (currently 33% of the Main Building walls) by more than 50% by framing in these openings with 2x6 stick framed, R19+ walls with high performance doors and windows. Glass is critical for bringing light into the sanctuary and for giving the feel that those inside are connected with the outside, but minimizing glass and building quality walls will maximize your energy savings with respect to these parts of the building.



Figure 20- Typical window wall extending to ceiling.

5.1.2.2 Recommendations for Concrete Walls

The tilt-up concrete walls with hexagonal perforations are probably the lowest performing walls in the buildings. Six inches of concrete has a lower R-value than the ¼” glass panels that are found throughout (R-0.66 vs R-0.88 ... yes, both below R-1). The many windows do offer some daylighting of the offices and library, but none that is available to congregants during the service. The congregation should determine what they want the walls to look like, then seal up the undesirable windows with insulating foam. The next step, however, will have the most impact on energy use. An insulating material should be added to the interior of the walls in the Main Hall portion of the Main building. Although the concrete walls offer excellent thermal mass for stabilizing the indoor temperatures, the building is occupied so seldom and irregularly that it would be undesirable to have the thermal mass exposed to the space. The reason for this is that changing the temperature of the space would take longer if the thermal mass was on the inside than the outside of the insulation. If this were a constantly occupied space (ie: like a residence) then having the thermal mass on the inside would be highly recommended. The ultimate R-value of the walls should be between R-11 and R-20. This may be achieved by either applying a spray foam product or by furring out from the walls with 2x4 or 6 frames and insulating in the cavities created. Unfortunately the furring method would take away six inches of floorspace around the perimeter of the building. It might be possible to find a spray on product that may be applied inside and outside the concrete wall to a depth of 1.5” (R-6 per inch, so R-18 total).

5.1.2.3 Recommendations for Wood Frame Walls in Classroom Buildings 2 & 3.

Replace aluminum windows (U-0.9) with Energy Star windows (U-0.35 or better). Open stick framed walls and install the best available insulation. Wet blown cellulose or Soy foam would be ideal, but Quality Installed R-15 batt would be an excellent substitute.

5.1.2.4 Recommendations for Roof of Main Building

Both the dome over the Main Hall and the flat roof over the offices and kitchen should be foamed up to 2 to 3 inches with a bright white reflective finish. In residences a higher R-value would be recommended, but with the inconsistent occupancy of this building, an R-19 roof should serve this space well. Before pursuing a roof of this sort, the congregation should take the following into consideration:

First, the congregation should determine if they want to add skylights to the dome to improve daylighting in the Main Hall space. However caution should be taken when selecting the skylight locations, size, opaqueness, operability and other options. As the Davis congregation has discovered, a long, clear skylight at the peak of the building can bring in a lot of natural light throughout the year, but the skylight allows direct summer sunlight to beat down on a bank of seats during the 11 am service, making a whole row inhospitably hot, and unusable. Some recommendations for skylight selection are as follows:

- Select skylights with opaque glass or with external shading screens to prevent direct sunlight hitting the congregants
- Select operable skylights to allow relief of hot rising air on hot summer days
- Locate skylights to provide daylighting during most seasons

Second, the congregation should determine whether they want to install PV or solar DHW panels on the flat portion of the Main Building at some future date. If they do (and I highly recommend it) then the stanchions, wiring and piping for the future installation should be installed before the roof is foamed up. Making concessions for this future installation now will save a lot of money and labor down the road.

5.1.2.5 Recommendations for Roof of Classroom Buildings

Add additional foam to reach a total of 3” of foam. Shop around for an affordable foam roof installer. Some installers will charge 10 times what others will. Soy foam is available for this application.

5.1.3 Recommendations for HVAC Improvements and Renewables

There are many options for efficiently heating and cooling the buildings on the campus. Although some of the equipment is relatively new (3 year-old system in office, recently replaced condenser unit on Classroom Building 3), the majority of the equipment is outdated and inefficient. Renewables are somewhat tied to the HVAC strategy that is pursued, so these two subjects will be combined in this section. The following is a discussion of some the concept of a Zero-Energy campus, which is the pinnacle of energy efficiency.

The term Zero-Energy is still being defined as the industry explores new ways of saving energy in buildings. Typically, the engineer on a zero energy project tries to make as

much of the appliances electric as possible and the building as efficient as possible at keeping the occupants comfortable. Sustainable and renewable energy devices are then used to generate the energy needed to operate and condition the building. Because most building owners want gas-cooking appliances and because gas water heaters and furnaces work more efficiently than their electric counterparts, it is very hard (and/or expensive) in today's market to achieve True Zero Energy.

To truly be zero energy the UUSS campus would have to be powered entirely by energy generated on site. This would require that all heating and cooling equipment install must be electric. A Near Zero Energy strategy would involve a similar approach as the True Zero Energy approach above, but would not eliminate all gas appliances, and rather replace them with very efficient models.

5.1.4 Photovoltaics

Photovoltaics are a primary part of the Zero Energy strategy. The campus has consumed an average of 65 MWh per year over the last two years, but only consumed 51 MWh in FY 2004. It is safe to assume that without the catering service renting the kitchen, the energy consumption should go back down to previous levels. If the second strategy (envelope improvements) and/or the third strategy (HVAC improvements) are pursued, then the PV system must be sized for the new consumption numbers. Table 5 shows the estimates for cost of materials and labor for different array sizes based on the following assumptions:

- PV cost after rebate will be \$5.00 per Watt
- Cost of inverters is \$4,000/7.5kW
- Additional hardware will cost \$1000/kW

These values are very rough and represent system cost after rebates and tax incentives. If it is decided that the Zero Energy strategy is to be pursued, electric use will rise in some places where gas equipment is replaced with electric. Assuming that envelope improvements and HVAC upgrades (conversion to all electric) yield a 50% savings in energy use, then a 67 kW PV array should provide all of the energy needed to operate the campus. At around \$439K, and a savings of up to \$17K per year, the simple payback on this system would be 25 years. Use this table to run other scenarios under consideration.

Table 5 - Amount and Cost of PV by strategy and predicted energy savings.

	Electric (kWh)	Gas Use Equivalent (kWh)	Total elec equiv. (kWh)	Zero Energy		W/Gas	
				kW of PV	Cost	kW of PV	Cost
Historical Use	51,000	131,849	182,849	134	\$877,457	37	\$244,739
10%	45,900	118,664	164,564	121	\$789,711	34	\$220,265
20%	40,800	105,479	146,279	107	\$701,965	30	\$195,791
30%	35,700	92,294	127,994	94	\$614,220	26	\$171,317
40%	30,600	79,109	109,709	81	\$526,474	22	\$146,843
50%	25,500	65,925	91,425	67	\$438,728	19	\$122,370
60%	20,400	52,740	73,140	54	\$350,983	15	\$97,896
70%	15,300	39,555	54,855	40	\$263,237	11	\$73,422

5.1.4.1 Final HVAC and Renewables Recommendation

Because of the size and layout of the campus, a liquid based heating and cooling system is recommended to serve most parts of the campus from a single system with well insulate pipes. A liquid system is also very flexible, allowing installation, expansion and reconfiguration more easily than a ducted system.

Another benefit of a liquid based system is that it would allow a mixture of distribution systems. Since radiant floors offer the most in comfort (by most accounts), they should be used wherever possible. The Main Hall will lend itself nicely to the installation of a zoned floor tubing system floated over a layer of insulation. The wings area of the stage could be served by hydronic coils if mounting tubing to the bottom of the stage proves to be too difficult or impractical.

Another reason to go with water distribution rather than air is that the ducting for the large heating system in the Main Building is buried below the slab of the building, making it impossible to modify the duct runs beyond reconfiguring what is in the basement for zoning purposes.

The classroom buildings could either use hydronic coils or radiant floors fed from the same campus system. The radiant floors are highly recommended in the classrooms and offices too if they can be afforded.

The radiant floor system can be used for heating and cooling as long as very special care is taken to keep the floor temperature well above the dew point temperature of the air in the space. Another option would be to use the floor for heating and then use hydronic coils mounted in the overhangs around the perimeters of the meeting room for cooling.

The first choice for heating and cooling the water for this system would be a ground source, water-to-water heat pump (GHP) with hot and chilled water storage tanks. The wells could be drilled in the field to the west of the sanctuary, and would be undetectable once the sod was re-sewn, and the storage tanks could be installed in either the old loading dock or in the basement. These systems can be rather expensive due to the wells

that must be drilled. An alternative to the GHP system would be a high efficiency chiller and condensing gas fired boiler.

Depending on which of the sources are chosen (GHP or Boiler/Chiller) a renewables plan should be designed to supply as much of the electrical load as possible. Photovoltaic panels can be mounted on the flat portion of the Main Building, and on Building 1 of the classrooms. If some trees are trimmed, then Buildings 2 and 3 might be used too.

There are many examples of efficient systems out there, and more are designed and built every day. I recommend researching successfully implemented systems. The USGBC web site has case studies of sustainable buildings. Another source for innovative designs is within the UU Churches. The UU Fellowship of Northern Nevada (in Reno) was designed to have efficient comfort systems similar to those outlined above. The UU Church of Fresno is currently completing their LEED project, and some other UU Churches have been featured in UUniverse magazine.

6 Final Notes

6.1 Proposed Policies

It is recommended that a “Green Team” (possibly a subset of the green sanctuary group) be formed. The team would be responsible for making a list of events or activities that will trigger team involvement. (Maintenance plan, Appliance purchase, re-roofing, new building, re-model, energy updates). When called upon, the team would establish a list of options with sustainability, energy savings, cost, payback and other issues listed for comparison, and present this list to the decision making body with recommendations on the purchase.

6.2 LEED Certification

The US Green Building Council has developed several points rating systems for various types of building and remodeling projects. The Leadership in Energy and Environmental Design (LEED) points system for New Construction is used in cases of new buildings and major remodels. The LEED Existing Buildings system is designed for minor remodels and rating existing buildings. Each rating system includes required measures to ensure some best practices, and optional credits that allow the owners to choose what level of “Greenness” they would like to achieve. Depending on the number of credits achieved, the building can be awarded a Certified, Silver, Gold or Platinum designation.

The LEED Certification processes are voluntary programs designed to help the building owners ensure that their desired level of systems performance, energy efficiency and sustainable building practices are met. The Certification itself is intended to back up the owner’s claims of “Greenness” in times of selling the building or appealing to investors or lenders for funding. Certification also gives bragging rights to the owner (ie: UU church of Fresno is striving for Gold certification, UU church of Portland Oregon has achieved Gold Cert., etc.). The rating system encompasses several green aspects of the building process. The main categories are as follows:

Table 6 - Main LEED NC Categories

Category	Issues addressed
Sustainable Sites	Access to public transportation. Deterring development on farmland. Preference for development on brownfield, infill and previously developed sites. Stormwater management. Reduction of Heat Islanding. Minimizing light pollution.
Water Efficiency	Wastewater minimization and treatment. Efficient irrigation and domestic water use.
Energy and Atmosphere	Minimize energy consumption. Maximize building performance. Avoid the release of refrigerants into atmosphere. On-site renewable energy. Verification of efficient systems performance. Green Power.
Materials and Resources	Storage and collection of recyclables. Reuse of building components and materials (in remodel situation). Diversion of construction waste from landfill. Using recycled content and regional materials in construction. Using rapidly renewable and certified sustainable products in construction.
Indoor Environmental Quality	Maximize indoor air quality. Optimize indoor thermal comfort. Increased ventilation. Use of daylight for illuminating indoor spaces. Access to views of outdoors from indoor spaces.
Innovation and Design Process	Use of innovative solutions to sustainability related issues.

Credits are awarded in each category for incorporating the green measures as shown in Table 7.

Table 7 - LEED Certification Levels for LEED NC v2.2 and points required

LEED Certification Level	Points Required
Certified	26-32
Silver	33-38
Gold	39-51
Platinum	52-69

It is strongly recommended that LEED Certification be pursued, and that the highest Level possible be attempted. The LEED rating systems are weighted towards best practices, and following them will ensure a high-quality, green building.