**Introduction**

Our topic for the Net Zero charrette was Generation. We first broke this up into systems dealing with primary elements, wind, water, solar etc. Then we investigated systems in each of these areas to address moving the College of Architecture and Planning building toward Net Zero. Our research led us toward some very diverse systems and methods.

Indoor Grey Water Reuse- to generate a non-potable water supply to flush toilets

Hydro-Turbine power (integrated into plumbing)- to generate electrical power

Solar Hot Water- to generate a renewable hot water supply

Distributed Solar Thermal Power- to generate electrical power to run building systems, electrical power, etc

Hybrid Solar Lighting- to generate a healthy renewable light source

These topic areas will be outlined individually and will address the following; our research method, why architects should be familiar with the system, the future implications for Net Zero buildings and finally examples of each system in use.

**Greywater**

Our first step in researching grey water recycling and its potential was to examine Utah State law regarding its use. Utah Law does not allow greywater to enter the groundwater in any way.

(c) Graywater shall not be:

(i) applied above the land surface;

(ii) applied to vegetable gardens except where gray water is not likely to have direct contact with the edible part, whether the fruit will be processed or not;

(iii) allowed to surface; or

(iv) discharged directly into or reach any storm sewer system or any waters of the State.

This greatly limited what is capable with a grey water system in Utah, since most focus on reuse in the landscape or purification through landscape systems. For this reason we chose to focus on reuse within the building for flushing toilets and irrigating planters.

Given Utah’s arid climate water conservation and reuse is vitally important. Grey water recycling presents the possibility of limiting the use of fresh clean drinkable water a very finite resource. Here at the College of Architecture and Planning we have the opportunity to almost complete the water cycle within the building and reduce our freshwater use drastically. Current usage points toward our greatest water use being from flushing toilets, if we could instead flush those toilets with grey water we could reduce our water use by well above 50% percent. Additionally grey water
could be used to irrigate planter beds inside/outside the building. Our stairwells currently have shelves built into the railing system. Let’s utilize these in a sustainable and beautifying way.

Architects are the specifiers and controllers of all elements that go into a building from finishes, to fixtures, plumbing systems, HVAC systems and so on. By carefully considering all of the elements as an integrated system we can increase interdependency and decrease a buildings reliance on exterior sources. The water cycle in a building is one of the more simple systems to re-engineer away from a traditional source to waste method.

The future for grey water recycling is integrating collection systems, purifying systems, human waste recycling and grey water systems to allow a building to be completely disconnected from the sewer grid. This would create a complete natural self sustaining cycle encompassing the building.

Sources
http://en.wikipedia.org/wiki/Greywater
http://www.greywater.net/

**Water Turbine Power**

Another power generation source could be the use of water turbine power. Turbines would be located in main water supply line as the water source. The water would be converted to high pressure renewable energy. This system is basically an updated version of the old mills that were turned by water for energy. This type of power generation would reduce greenhouse gases as the source is from the flow of water.

In looking at what internal functions could be utilized for power, we determined water certainly could be used or reused in some fashion. Testing has been done for existing water transmission pipelines indicating water flow need not be disrupted by tapping into normal pipeline operations. The system, through Northwest Pipe Company and Lucid Energy Technologies, LLP, will be available in 2010. We also discovered the City of Carlsbad, California was using the water source from a reservoir to produce hydro electric power. This was going to help economically as it would pay for itself within five years, socially since it is the right thing for the city to do to reduce greenhouse gases, and environmentally as it would reduce greenhouse gases.

Hydro power is an energy source that is important for architecture because it utilizes a natural source and is available to anyone connected to the main water lines. This could potentially be used on large and small scales. This source is also taking advantage of something that is already occurring in mechanical systems. To add turbines to use this source would be using the same source for two uses.

**Active Solar Domestic Water Heating**

The research we did on Solar Water depicts it as one of the most inexpensive/environmentally friendly sustainable strategies available at domestic level.

Solar water heating systems use solar panels, called collectors, fitted to your roof. These collect heat from the sun and use it to warm water which is stored in a hot water cylinder.
The active water systems that can be used to heat domestic hot water are the same as the ones that provide space heat. A space heat application will require a larger system and additional connecting hardware to a space heat distribution system.

**Cost and savings**

**Costs** for a typical solar water heating system range from 4,800$ to 8,000$ USD. **Savings** are moderate - a solar water heating system can provide about a third of your hot water needs, reducing your water heating bill by between £50 and £85 per year. It will also save up to 580kg of CO2 emissions, depending on what fuel you will be replacing. **Maintenance** costs are very low. Most solar water heating systems come with a 5-10 year warranty and require little maintenance. You should take a look at your panels every year and have them checked more thoroughly by an accredited installer every 3-5 years, or as specified by your installer.

There are five major components in active solar water heating systems:

- Collector(s) to capture solar energy.
- Circulation system to move a fluid between the collectors to a storage tank
- Storage tank
- Backup heating system
- Control system to regulate the overall system operation

There are two types of solar water heating panels, they are evacuated tubes (like in the picture above) and flat plate collectors. Flat plates collectors can be fixed on the roof tiles or integrated into the roof.

Larger solar panels can also provide energy to heat your home as well - though usually only in the summer months when home heating is unnecessary.

There are two basic categories of active solar water heating systems - direct or open loop systems and indirect or closed loop systems.

**1 Direct Systems**

The water that will be used as domestic hot water is circulated directly into the collectors from the storage tank (typically a hot water heater which will back up the solar heating).

There are two types of direct systems - draindown and recirculating. In both systems, a controller will activate a pump when the temperature in the collectors is higher than the temperature in the storage tank.

The draindown system includes a valve that will purge the water in the collectors when the outdoor temperature reaches 38 degrees. When the temperature is higher than 38 degrees and the collectors are hotter than the storage tank, the valve allows the system collectors to refill and the heating operation resumes.

The recirculating system will pump heated water from the storage tank through the collectors when the temperature drops to 38 degrees.

These two systems have serious drawbacks. The draindown valves can fail in a draindown system and the result can be the expensive breakage of the solar collectors. The draindown valve will typically sit unused for a very long time and then will need to work the first time without failing. The cycling of air and water in a draindown system collectors as a result of periodically draining down (thereby emptying the collectors) can cause a buildup of mineral deposits in the collectors and
reduce their efficiency. The recirculating system circulates buildup from potable water heated from the storage tank through collectors during potential freeze conditions and effectively cools the water (wasting energy).

2 Indirect Systems

Systems that use antifreeze fluids need regular inspection (at least every 2 years) of the antifreeze solution to verify its viability. Oil or refrigerant circulating fluids are sealed into the system and will not require maintenance. A refrigerant system is generally more costly and must be handled with care to prevent leaking any refrigerant.

An indirect system that exhibits effectiveness, reliability, and low maintenance is the drainback system. The drainback system typically uses distilled water as the collector circulating fluid.

The collectors in this system will only have water in them when the pump is operating. This means that in case of power failure as well as each night, there will be no fluids in the collector that could possibly freeze or cool down and delay the startup of the system when the sun is shining.

This system is very reliable and widely used. It requires that the collectors are mounted higher than the drainback tank/heat exchanger. This may be impossible to do in a situation where the collectors must be mounted on the ground.

An indirect or direct system can be used for heating swimming pools and spas. Lower cost unglazed (no glass cover) collectors are available for this purpose.

The fluids that are circulated into the collectors are separated from the heated water that will be used in the home by a double-walled heat exchanger.

A heat exchanger is used to transfer the heat from the fluids circulating through the collectors to the water used in the home. The fluids that are used in the collectors can be water, oil, an antifreeze solution, or refrigerant.

A boiler or immersion heater can be used as a back up to heat the water further to reach the temperature set by the cylinders thermostat when the solar water heating system does not reach that temperature. (The cylinder thermostat should be set at 60 degrees centigrade.)

The heat exchangers should be double-walled to prevent contamination of the household water.

The controller in these systems will activate the pumps to the collectors and heat exchanger when design temperature differences are reached.

The heat exchanger may be separate from the storage tank or built into it.

To tell if solar water heating is right for you, there are a few key questions to consider:

- **Do you have a sunny place to put solar panels?** You'll need around 5 square metres of roof space which faces east to west through south and receives direct sunlight for the main part of the day. Alternatively, if you do not have a south facing roof and if you have space, you could install two panels, one facing east and one facing west - but this will make installation more costly. The panels don't always have to be mounted on a roof, they can be fixed to a frame on flat roofs.

- **Do you have space for a larger, or an extra, hot water cylinder?** If a dedicated solar cylinder is not already installed then you will need to replace the existing cylinder, or add a dedicated cylinder with a solar heating coil.

- **Is your current boiler compatible with solar water heating?** Most conventional boiler and hot water cylinder systems are compatible with solar water heating. If your boiler is a
combination boiler (combi) and you don't currently have a hot water tank then a solar hot water system may not be compatible.

The benefits of solar water heating

- **Hot water throughout the year**: the system works all year round, though you'll need to heat the water further with a boiler or immersion heater during the winter months.
- **Cut your bills**: sunlight is free, so once you've paid for the initial installation your hot water costs will be reduced.
- **Cut your carbon footprint**: solar hot water is a green, renewable heating system and doesn't release any harmful carbon dioxide or other pollutants.

**Hybrid Solar Lighting and Distributed Solar Thermal**

While attempting to uncover interesting systems of energy generation that aren't well known or covered by other groups, we discovered two interesting and potentially important topics. Distributed solar thermal energy and hybrid solar lighting are what we encountered.

The first system that we stumbled upon is known as distributed solar thermal energy generation. It works by using large solar tracking mirrors, or heliostats, to focus the sun's rays into a solar collector. Upon reaching a sufficient temperature, the collector is able to use the thermal energy to turn a turbine that produces electricity. The earliest precedence of this technology, that we could find, occurred in 2006. These early attempts were limited in that they were steam-based systems that could only supply energy while the sun was shining. A good example of the latest iteration of this type of system was unveiled in February of 2009 by the Aora company in Israel. In conjunction with the Haim Dotan architecture firm, Aora produced what has been dubbed “the power flower”. This project has a few new twists on the DST technology that may prove to move its usefulness forward. Among them are its modular design which make it highly scalable, transportable, as well as easily assembled and duplicated. The system is also hybrid, allowing to produce energy while the sun is down using a variety of alternative fuels. It is capable of producing 100 kw hours of energy which the company claims is enough to power 50-70 homes. In an e-mail to the company we inquired as to whether or not they would be producing smaller systems that could be used in single building applications, Aora responded that no plans for smaller systems are in place at this time. They did, however, state that larger systems were being designed and that they were working on developing technology that allows them to store the electric and thermal energies more efficiently. This has potential implications in our program's quest to make our building a net-zero structure in that if we could develop a similar system, we could potentially feed excess power into the grid. This power could be used for other building on campus or in the community.

Hybrid solar lighting is a system that we encountered as a by-product of finding the DST technology. Both systems use mirrors to harness the sun’s energy and seem to be informing each other as to how this kind of science might be expanded and applied to other uses. With hybrid solar lighting, the sun’s visible rays are distributed throughout a building using fiber optic cables. Sun tracking mirrors are mounted on the rooftop. Using a double mirror system the UV and infrared rays are stripped leaving only the visible light. This light is then fed into the fiber optic cables that are distributed throughout the building. The fiber optics are coupled with fluorescent or incandescent bulbs that can be ramped up when the sun is not shining.

This kind of system has a number of positive aspects. Some estimate that 30% of all energy used in the US is for lighting alone. It is also contested that too much artificial light has psychological
implications such as seasonal depression. Oakridge National Lab and Sunlight Direct have been working with the technology since 2006. According to their research, retail sales are higher, and employees are more productive when hybrid solar lighting or natural light is used in the building. They also estimate that if this technology were used only in the “sun belt” region of the US, 20 billion kw hours of electricity and 1.5 million metric tons of CO2 would not be produced annually. Currently these companies are working towards using the technology for solar water heating, infrared heating, and hydrogen production systems.

These two technologies are good examples of how we might further use the sun’s energy beyond or in conjunction with more traditional photovoltaic systems.

**Conclusion**

The potential for these systems is tremendous. Some of them could individually provide power and move the building entirely off the power supply grid. Moving towards net Zero is a complex process and requires that we first take the building energy demands down then integrate systems to generate the required energy for daily functioning. In our case here Net Zero would most likely be accomplished by a combination of on-site generative methods and off site renewable energy production that would result in a net carbon output of zero. Unfortunately certain renewable generative methods are prohibited in Utah for example rain water harvesting. Other areas of our research like solar thermal power, hybrid solar lighting and solar hot water show great promise given Utah’s climate and regulations. Net Zero doesn’t have any “magic bullets” it requires thoughtful planning and integration of conservation, generation, operation + maintenance and resource management.