Resource Efficiency Technical Document

Achieving greater energy and resource efficiency and finding more sustainable energy sources is a key factor in achieving more sustainable operations. We have reviewed existing energy use of the Linden Centre and what resource efficient practices and features already exist, what can easily be added, and opportunities for taking a more holistic, systems view on achieving energy and resource efficiencies.

Key activities where efficiencies are recommended include:

- General
- Building
- Cooking
- Cleaning
- Transportation
- Waste

For each area, the team has reviewed what the current trends in energy sourcing and resource efficiency are, in particular for places of a similar scale, size and nature. Overall, proposals have been allocated between actions that can be taken immediately today and actions that can be planned for the future. Support mechanisms for operational changes have also been proposed.

In addition, synergies have been sought between energy-intensive activities, taking a systems approach to the energy system in order to maximize efficiencies. The team has also investigated whether more energy efficient systems can be created through economies of scale with the surrounding community creating a win-win situation. Sustainable energy sourcing at the local level has also been explored.

For the Linden Centre, as a single, private business, with regard to community scale projects, we recommend the most appropriate role for the Centre is a stakeholder and a champion for sustainability projects and planning, rather than taking on the primary or sole responsibility of planning or leading the implementation of community scale projects. This is particularly important for Linden Centre’s goals of controlling costs associated with its sustainability initiative.

General

Energy efficiency

The National Development and Reform Commission of the People’s Republic of China (NDRC) commissioned models for the China’s National Climate Change Programme and Pilot Provincial Climate Change Programmes (Draft). These models forecast temperatures rising and
precipitation increasing in Yunnan Province\(^1\). In regards to energy, forecasted conditions will have numerous effects on the Yunnan Province and potential direct effects on the Linden Centre.

Currently in the Yunnan Province, the wet season (May to October) runoff accounts for 73-85% of the water for the year\(^2\). The remaining rainfall (15-28%) occurs in the six months from November through April. The NDRC draft document reports that currently the Yunnan province cannot meet its water resource needs due to distribution and some areas are experiencing severe shortages\(^3\). The three annual electricity rates provided by the Linden Centre staff reflect prices based upon hydropower availability. It is expected if water supplies become more unevenly distributed throughout the year due to inter-annual precipitation variation that prices will become more volatile. As development of the region continues so will energy demand in turn exacerbating energy demand issues resulting from climate change. Therefore to confront energy price volatility, it is important for the Linden Centre to address energy consumption and begin implementing energy efficiency and conservation steps along with exploring alternative and renewable energy options.

The Linden Centre is already implementing several energy saving practices such as limiting the number of entertainment appliances such as televisions and radios, as well as line drying guest laundry and hotel linens. An easy and inexpensive way to expand the Centre’s general energy efficiency is to ensure staff awareness of best practices, particularly in cooking and dishwashing. Longer-term goals include installing room card-key switches which automatically turn on and shut off energy consumption as guests enter and leave rooms. Additionally, the Centre could install a digital dashboard which allows guests to get real time feedback on energy consumption. This increased awareness of consumption can lead to dramatic reductions in energy use of guests and staff.

**Water efficiency**

The USDOE Federal Energy Management Program states water efficiency measures not only save water, but also save energy used in heating and pumping\(^4\). Water use is directly tied to energy consumption both internally and externally at the Linden Centre and includes: the sourcing, the initial treatment, the onsite use and the removal of wastewater. Wastewater may be treated at the nearby wastewater treatment plant in the future offsetting the current costs of pumping and hauling. Therefore, addressing water consumption is an important step in addressing energy efficiency goals and achieving the sustainability goals of the Linden Centre. By reducing water use in each aspect of daily operations the Linden Centre will reduce the costs of energy and water consumption and reduce greenhouse gas emissions.


We understand that guest comfort is important to the Linden Centre and therefore researched water efficiency case studies in the hospitality industry. A case study by the United States Green Building Council (USGBC) in partnership with various hotels found water cost savings from these upgrades increased hotels’ profits without harming guest experience and certain technologies had a return on investment of less than one year⁵.

The Linden Centre has a large underground storage tank that is supplied by the public water supply (PWS). Electric powered pumps make the stored water available for use in the hotel. In the case of a power outage, a diesel generator provides electricity for the pumps and ensures a reliable water supply. In summary, at the Linden Centre electricity consumption is directly related to water use. Although, it is likely that an effort by the Linden Centre to reduce PWS water consumption may not significantly affect energy consumption in the community it may result in a cost savings.

While community wide water use conservation should be addressed, we chose to focus on internal efforts to increase energy efficiency related to water use. Therefore, this aspect of the report will focus on energy efficiency related to water consumption within the scope of the Linden Centre’s operations and assumes that water use is tied directly to the organization’s electricity consumption. A separate chapter on water discusses water consumption as it relates to sustainability and cost reductions from the water bill. In summary, it is likely that internal cost savings related to water consumption can be achieved in the forms of grid electricity and to a smaller extent generator fuel consumption.

The following sections start with and include energy efficiency information as it relates to the pump and finishes with daily water consumption at the Linden Centre.

The components of the water supply system are integral variables of energy efficiency. Changing conditions of the system affect the efficiency of the pump and therefore the energy consumption of the pump and energy sources of the pump⁶. The following factors determine efficiency and warrant monitoring by the Linden Centre: pump efficiency; pump maintenance; volume of water in the storage tank; and volume of water used. Based upon recommendations by The Center for Irrigation Technology routine pump testing and monitoring can aid in determining whether energy efficiency can be increased and energy costs reduced. Additional variables that determine energy efficiency related to the system include: is the pump an on demand pump or is water pumped to a holding tank and pressurized ((T. Howorth, personal communication, February 10, 2012)). Statements regarding fuel consumption of a generator as it relates to this type of system are dependent upon size of generator, fuel, load and operating hours. A chart providing an approximation of diesel fuel use based upon these factors is found in Appendix A.

In the case of the Linden Centre, the consumption of water by guests and the staff is directly related to energy efficiency of the water supply system and the heating of hot water. The energy efficiency group identified the following energy efficient products for potential

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implementation at the Linden Centre and provides the business case in the following paragraphs:

- high efficiency faucets (aerator or laminar flow)
- low flow shower heads
- high efficiency tank type toilets
- dual flush toilets

The USEPA Watersense® program estimates a 30% reduction in water consumption by using the residential lavatory faucet efficiency technologies listed above\(^7\). Flow rates for WaterSense® faucets are rated at a maximum of 5.7L/1.5 gallons per minute (gpm). Faucets intended for public use are specified by the American Society of Mechanical Engineers (ASME) and Canadian Standards Association (CSA) and are allowed a max flow rate of 1.9L/0.5 gpm\(^8\). In contrast post 1994 faucets in the United States were limited to a max flow rate of 9.5L/2.5 gpm. Therefore, provided the existing faucets are comparable to US standards, if the Linden Centre were to retrofit existing faucets with these technologies it is likely that a 30% reduction in water consumption would be possible.

Similar to the faucet technology, the WaterSense® program estimates a 20% reduction in water consumption for low flow showerheads with a max rated flow at 7.6L/2.0 gpm\(^9\). In addition, the WaterSense® program limits the max flow rate of kitchen faucets to 8.3L/2.2 gpm through the use of aerators or laminar flow devices.

The USEPA’s WaterSense® program estimates a 20% reduction in water consumption by using high efficiency tank type toilets. This reduction translates to a minimum savings of 2650L/700 gallons per year per toilet\(^10\). An additional option is a two-button toilet. While most low flow toilets use 5L/1.3 gpf, two button toilets use 2.6Lpf/0.7 gpf and 3.4Lpf/0.9 gpf\(^11\). The following website provides a calculator to determine consumption based upon number of toilets, gallons per flush and daily use.


**Building**

**Historic Preservation**

The Linden Centre’s preservation of a nationally protected heritage site is inherently sustainable. Given the historic value of the site, the decision to restore this relic is a win for

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\(^9\) USEPA. (2012a)

\(^10\) USEPA. (2012a)

preserving the cultural and historical heritage of Xizhou. Additionally, historic preservation is the more resource efficient choice as well. The National Conference of State Historic Preservation Officers (NCSHPO) points out that existing buildings represent a great renewable resource.\textsuperscript{12} Eliminating the resource and energy consumed in demolition of old buildings and new construction is an important benefit of historic preservation.

**Comfort Conditioning**

Heating at the Linden Centre is currently limited to the dining room, where it is provided through radiant sources: a fireplace and small “space heaters.” To discuss heating strategies, we should probably abandon the term “space heater” because radiant sources, rather than heating air within a space, technically heat objects, and significantly, people within a space. Thus a bonfire in the open air can deliver “sensible heat” very effectively without increasing the ambient air temperature, or more absolutely, the sun’s radiant energy heats the earth across the vast cold void of space.

Temperature comfort can be controlled by managing the transfer of heat energy in the three ways that heat moves: conduction (through solids), convection (through liquids or gasses), and radiation (through space). Three strategies, respectively, insulation, physical barriers, and reflectance impede that transfer. So, the Linden Centre’s glass-roofed dining room, heated by radiant sources, may lose significant radiant energy during the night-time (especially on clear nights) through night sky radiation through its transparent roof. Enhanced physical barriers, such as caulking, will help reduce heat loss due to convection such as infiltration (reducing draftiness). Better thermal insulation will reduce heat loss through solid materials due to conduction.

Given the challenges the Linden Centre’s historic structure presents to achieving tight, well-insulated spaces, radiant heat may be the best heat source for most uses. Most radiant heat is localized; electric resistance heaters can become immediately effective when activated by users; and they can be equipped with adjustable timer switches that turn them off. On the other hand, electric radiant heat is inherently inefficient.

Radiant floor heating can be much more efficient, even when its source is electric resistance heat, especially when it is incorporated into a concrete and/or masonry floor because the radiant source heats the floor by conduction, leveraging its thermal mass into a much more effective source of radiant heat for an entire space. Conduction through the floor into the occupants’ feet and convection within the space also collude to enhance the effectiveness of a floor’s source for sensible heat. On the negative side, radiant floor heating is not nearly as immediately effective as direct electric elements, however, and the time lag associated with thermal mass radiation also means that the floor will continue to radiate long after the source has been shut down. Thus a radiant floor is not a good choice for knocking off the morning chill when the day will become warm; rather, it is a good choice when a level of heat demand will persist for hours and days.

\textsuperscript{12} National Conference of State Historic Preservation Officers, 2010. *Historic Preservation: Support for Retrofits of Older and Historic Buildings*

A better heat source for radiant floor heating is hydronic heating, consisting of hot water (or other liquid media) circulating through coils set in or below the concrete or masonry floor. The liquid media should be a closed loop that recirculates through a heat source, possibly a low temperature boiler, or more optimally, a heat pump. The heat pump system can utilize a ground source heat sink, which can be wells in the ground, horizontal trenches generally two meters deep, or slinky loops of piping submerged in a body of water. Heat pump systems, as the name implies, transfer and concentrate heat energy rather than generating it. In contrast to air source heat pumps, water source or ground source heat pumps are more effective because they exchange heat in a more concentrated and higher temperature media (water), referred to as a heat sink. Water in a loop is pumped in a loop through the ground (a series of trenches or wells or at the bottom of a lake [such as Erhai]) to the heat pump, where the heat is concentrated through expansion. It can then be delivered to a sub-floor loop (or alternatively, a fan coil) where its heat is delivered to the served space. Then the loop continues back to the sink to regain its lost energy.

The heat pump can also serve as a source for pre-heating domestic water (using the heat from the loop, not the water itself), but it will require a supplemental heat source in order to raise its temperature from the 110 degrees F needed for the radiant floor to the 140 degrees F (or 160) needed for domestic hot water. Still, this is much more efficient than starting with cold water. Peak demands are often at different times, especially as a floor’s thermal storage capacity permits the temporary diversion of heating capacity.

Waste heat from other equipment, such as water-cooled compressors for icemakers, walk-in coolers, and refrigeration equipment can be harvested and can contribute heat to the geothermal loop. Geothermal systems are ideally applicable to larger complexes of buildings or even entire neighborhoods, where diverse local needs drawing on a single central loop (or series) effectively shave peak demand and should reduce the aggregate size of the central plant equipment. The entire village of Xizhou could develop a central loop system that utilizes Erhai as a heat sink.

**Lighting**

Managers of historic properties focused on sustainability can often find some inherent gains related to lighting. One area to consider is the use of natural light, which is a short term ‘win’ for the Linden Centre today. Aside from the economic and environmental benefits, natural light has been shown to have positive effects on public health.\(^\text{13}\) Of particular interest to a guesthouse, like the Linden Centre, focused on the comfort of guests, natural light is important for the body’s circadian rhythm. This circadian rhythm controls certain physiological functions including sleep-wake cycles, and alertness levels, according to sources cited by Dr. Hobday for Historic Scotland. Of course, the impact of natural light on employees of the Linden Centre is another topic of importance related to the social component of sustainability.

The Linden Centre has multiple courtyards with reflecting white wall built in as a historic design feature maximizing the use of natural light. The guest rooms also provide natural light through

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several large windows. The dining hall boasts a glass ceiling ensuring the maximum amount of natural light is available in that common space.

Where artificial light is necessary, the Linden Centre can incorporate energy efficient lighting technologies to meet sustainability goals. If done incrementally, efficient lighting, such as LED bulbs, can first be placed in areas of most frequent use (guestrooms, lobbies, and hallways). Solar lighting is already being used for outside areas, but could be further expanded. Sensors can be placed in areas that are infrequently used, such as bathrooms. Education of guests and staff to turn off lights when rooms are unoccupied remains important for a low cost/no cost solution, while products like room card-key switches can automatically turn off lights when guests leave their rooms. The same result may occur with more-easily-installed occupancy sensors.

In areas of the Linden Centre that are lacking in natural light, another option is to look at certain technologies offer solutions that would not impede the historic sightlines of the property(ies). The schematic shown in Figure X, below, explains one such technology - light tubes, which act as skylights that direct sunlight into areas that do not otherwise have ample natural light. [Insert Figure X. Source: dcrinteriors.com] The United States National Parks Service (U.S. NPS) recommends light tubes for sustainability projects on historic buildings. Given that the most efficient unit of energy is the unit of energy not consumed. Utilizing such technology will allow the Linden Centre to avoid or reduce energy consumed to light its buildings during the day.

Water heating

The average household in the United States uses 14% of total energy consumed to heat water. The Linden Centre has already integrated hot water saving measures, such as limiting the time in which the water heater is used to two four-hour periods a day. In this section we will highlight additional no/low cost measures can be taken to reduce the amount of energy used to heat water, as well as introduce new technologies that can help decrease energy and water consumption.

Up to 90% of the cost of operating dish and clothes washing machines is associated with the energy used to heat the water. High efficiency dishwashers and washing machines can lower hot water usage, especially when they are paired with best practices for washing. These practices include running your dish and clothes washing machines only when fully loaded. Limiting the number of loads reduces both water and energy use.

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It is understood that the Linden Centre washes dishes by hand. Although the reason for hand washing dishes was not communicated, the energy efficiency team is providing the following information that supports the purchase of dishwashing equipment. Based on residential United States calculations an ENERGY STAR dishwasher will save the Linden Centre water, energy/fuel, time, will improve cleaning, and reduce contributions to air pollution. Residential size ENERGY STAR dishwashers use less than 16L of water per cycle. Overall, in the United States using a dishwasher saves $40 annually on utility bills. For the Linden Centre, the cumulative business savings are important. One residential ENERGY STAR dishwasher will save a minimum of 230 hours of labor per year, clean more efficiently all while using 50% less energy and a minimum savings of 19,000L of water. The ENERGY STAR program further supports using a dishwasher as it estimates that by simply not rinsing before using a dishwasher can save 75L of water whereas, in contrast an ENERGY STAR model uses less than 16L per cycle. In addition, the following dishwasher calculator will allow the Linden Centre to determine savings and return on investment specific to their operations (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?f6d0-b786).

If the Linden Centre does choose to install a dishwasher the following best practices should be followed:

- scrape food from the plate rather than rinse
- run full loads whenever possible.
- use the no-heat drying option to use less energy

In summary, installing and using a dishwasher will save the Linden Centre water, energy/fuel, time, will improve cleaning, and reduce contributions to air pollution.

Another way to reduce the amount energy used in heating water is to lower the temperature of the water heater to 120 degrees or lower. Thermostat dials are often inaccurate therefore, ensure that the thermostat is working correctly by testing the temperature with a thermometer.

By simply cleaning and maintaining existing appliances, the Linden Centre can prevent wasting energy used to heat and pump water. For instance, a leaky faucet loses one-tenth of a gallon per minute, wasting more than 50,000 gallons over the course of a year. Consider the cost of the same leak if it were hot water.

A low-cost alternative to purchasing a high efficiency water heater is adapting the Linden Centre’s current water heating system by adding insulation. Adding insulation to an electric storage water heater tank is relatively easy and affordable to install and it can reduce heat losses by 25%–45%. An additional 4% - 9% water heating energy can be saved by preventing heat loss into the floor by placing a piece of rigid insulation under the tank of a electric water heater.

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21 USDOE 2011
Another way to lower heat loss in water heating is by insulating hot and cold water pipes. Insulating pipes within 6 feet of the water heater reduces heat loss and can raise hot water temperature 2°F–4°F, resulting in a lower hot water temperature setting\textsuperscript{22}. Additionally, guests and staff will not have to wait as long for the water to heat up, which also helps to conserve water.

Finally, adding heat traps to the Linden Center's hot water heater tank can save energy, if they aren’t currently included. Heat traps prevent convective heat losses through pipes going in and out of the tank. Traps are usually inexpensive, but require installation by a qualified plumbing and heating professional.

\[\text{http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12760}\]

The types of high efficiency hot water heating appliances and their annual savings are:
- electric heat pump water heaters (50% savings annually)
- gas storage ($30 annually)
- gas condensing (30% annually)
- solar water heater (50% annually)
- gas tankless (30% annually)

All estimated savings are based on a comparison of a standard appliance to a high efficiency appliance of the same fuel/energy types. Savings improve as the number of individuals in the household increases. Solar water heaters require a back up system and generally have a payback period of 10 years\textsuperscript{23}. However, the lifespan of solar water heaters is approximately 20 years in comparison to a 13-year lifespan of a standard system. Gas tankless systems also have an expected 20-year lifespan, take up less space and decrease the chance for damage by leaks that are possible from tank type water heaters. Appendix C provides a comparison table by type of water heater with the efficiency value, installed cost, yearly cost, life span and total cost over a set period.

In summary, savings due to a hot water heater retrofit are dependent upon the type of system used by the Linden Centre. Retrofits may yield up to a 50% savings per year in hot water heating and an appliance with a greater lifespan increasing savings and reducing overall greenhouse gas emissions.

**Alternative energy sources**

Due to various feasibility reasons, the group determined that solar and wind powered pumps should be included in technologies to be considered for the future. The two potential pump options are grid-interactive and off-grid systems. Both solar and wind options could use storage batteries to capture the respective energy and may serve as a back-up source of electricity should the grid be unavailable. Dependent upon the local utility service provider’s ability to use power from a grid interactive system the off-grid system may be the most feasible option. In this case, the wind or solar energy produced would be stored in batteries. Battery systems do increase the cost and maintenance of the system. It is expected that evaluations of site requirements and limitations, solar and wind availability and the ability of the utility service

\textsuperscript{22} USDOE 2011

provider to use the produced power will be necessary. From these evaluations future feasibility of both solar and wind power for the pumps will be determined.

**Cooking**

We understand that gas (presumably liquid propane) is the primary source of cooking fuel, but specific recommendations to improve energy efficiency might benefit from more specific information about current cooking techniques and technology employed: baking in ovens versus stove-top frying, sautéing, boiling, steaming, and so forth. Kitchen ventilation is another major energy consumer, serving at least two purposes: removing excess heat and removing/filtering grease, odors, and other intense or objectionable byproducts of the cooking process.

Are there any other fuel sources to consider for these processes? Electricity is unlikely, but charcoal or wood might be used for grilling, bringing its own set of environmental challenges at both micro and macro levels. Solar sources are probably impractical for widespread use except for special cases such as drying fruits.

Short of such heroic measures, many common-sense energy efficiency strategies are available, such as:

- using equipment that is as energy efficient as possible, use igniters instead of pilot lights;
- use air-cooled instead of water-cooled ice-makers and refrigeration equipment (there may be some exceptions to this advice noted in this report as providing synergistic opportunities;
- keeping equipment clean, and optimizing blue flames that heat most efficiently;
- warm up equipment as late as possible to satisfy the need and turn it off as soon as the use is over;
- utilize remote compressors on refrigeration equipment (including icemakers) to avoid adding more heat load to the kitchen;
- separate refrigeration equipment from cooking equipment so that the refrigeration doesn’t have to overcome a surcharged heat load;
- utilize variable speed ventilation equipment to match the service with the need;
- verify that equipment has sufficient ventilation space, whether it is refrigeration or heating equipment;

Given that the energy consumption of facilities with commercial kitchens is almost twice that of commercial buildings without kitchens, the payback for improving efficiency by as much as 30% facility-wide is immediate and dramatic. (Source: Baltimore Gas & Electric, http://www.bgesmartenergy.com/business/energy-solutions-business/commercial-kitchen-equipment, accessed 3/14/2012) The prospect of these gains provides a powerful incentive to make the improved efficiency a priority for capital improvement. Many equipment vendors are eager to provide financing terms in order to eliminate barriers to prospective sales.

Cooking and kitchen equipment generally provide the opportunity for useful synergies through heat exchange. What strategies might be explored to harness waste heat from the various kitchen processes. Waste heat from refrigeration, captured through ventilation or even waste-water lines can be captured and redirected to preheat water, which can then be used to heat air. One advantage of water-source heat pumps is that the water loop which connects to the heat
sink or active source can incorporate a variety of additional heat sources. The challenge is to achieve sufficient scale to justify the effort.

Refrigeration

Refrigerator use at the Linden Center was identified as an area for potential energy savings. The following section provides information about the appliance options, related savings, available calculators and best practices. The USEPA requires that Energystar® labeled refrigerators use 20% less energy than those not labeled as ENERGY STAR®\(^{24}\). Comparing same year model refrigerators, ENERGY STAR® yields at least a $165 savings during the appliance’s lifetime. However, energy consumption of refrigerators varies by age. An ENERGY STAR® appliance will yield savings of up to 40% over a 2001 refrigerator and $100 per year over 1980 model refrigerators\(^{25}^{26}\). The two energy consumption calculators found below will be useful for the Linden Centre to determine the organization’s potential savings through energy efficient refrigerators and other kitchen appliances.

- ENERGY STAR® residential refrigerator energy calculator\(^{27}\)
- ENERGY STAR® Commercial kitchen savings tools

The US Department of Energy suggests simple energy efficiency practices can be implemented regardless of the refrigerator type to help save energy. These practices include:

- setting the refrigerator in the range of 3°C to 4°C. The freezer should be set at -15°C. Long term storage freezers should be set at -18°C
- Check the seals of the refrigerator doors using a bill or piece of paper. Shut the door, if the paper can be pulled out easily the door needs to be tightened or the seals replaced.
- Cover liquids and food in the refrigerator. Moisture causes the compressor to work harder.
- Regularly defrost manual defrost freezers to remove ice buildup. Ice buildup leads to energy inefficiency.
- When purchasing refrigerator/freezers consider top freezer models which are more 10-25% more efficient than side by side refrigerator/freezers\(^{28}\)

In summary, in order to reduce related energy consumption the Linden Centre has the options of implementing best practices with existing refrigerator(s), replacing inefficient refrigerator(s) in the near future or replacing refrigerators at the end of their lifetime with energy efficient models.

Local foods

Another current energy efficient practice of the Linden Center is the use of local foods in meals cooked for guests and staff. Creating meals from ingredients grown locally cuts down on energy needed for transportation of food. One way to increase the benefits of this existing

\(^{25}\) USEPA. (2012c)
\(^{27}\) http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator
\(^{28}\) USDOE. (2012d)
practice is to share this information with guests by identifying where ingredients in guest meals are produced. A future goal would be to work with local farmers to adopt more sustainable farming practices. The ability to source organically grown produce would be a win for the Linden Centre and for the local community.

Cleaning

Laundry

While the Linden Centre conserves energy by line drying laundry, there is room to further conserve energy and water through best practices and a future purchase of a high efficiency clothes washer. The Linden Center currently uses a commercial sized clothes washer that uses 52 gallons of water per cycle (conservative estimate with calculations available in Appendix B). One load of laundry requires one wash cycle and three rinse cycles totaling an estimated 210 gallons of water. Linden Centre staff estimated, twenty-three individuals checking out yields three loads. Three loads of laundry equals 630 gallons or 2.3m3 of water or 2.3% of the Linden Centre’s underground storage tank. Information was not available clarifying the need for the two additional rinse cycles. It is suggested that the Linden Centre determine why these additional rinse cycles are required, eliminate them if possible or find a procedure to reduce this potentially excessive energy and water consumption.

Practical no or minimal cost first steps and best practices for the Linden Centre to reduce laundry energy consumption are:

- determine why the two additional rinse cycles are required and identify methods to eliminate or reduce this consumption
- wash clothes in cold water with efficient cold water specific detergents
- wash only full loads or adjust water levels based upon the load size.

Energy efficiency options greater than minimal cost include purchasing a high efficiency clothes washer to replace the current machine either at the end or before the end of its service life. In contrast to conventional clothes washers, ENERGY STAR labeled clothes washers use nearly 50% less water than a standard washer, have greater capacity and use 37% less electricity. For comparison, a residential sized ENERGY STAR washer only uses 53L/14 gal of water compared to 102L/27 gal of water of a standard washer. From an electricity standpoint and based upon average US residential use (300 loads/yr), electricity expenses of one ENERGY STAR machine costs 60 USD per year. In summary, one washer could save the Linden Centre from pumping a minimum of 163,000L/43,000 gal of water in the lifetime of the machine or 50% of the water per load and reduce consumption of energy used in operation of the machine.

The following clothes washer savings calculator will allow the Linden Centre to determine savings specific to their operational needs (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls?c7fe-7943).

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31 USEPA. (2012b)
In summary, in order to reduce related energy consumption the Linden Centre has the options of implementing best practices, replacing clothes washer at the end of its lifetime or replacing the existing clothes washer prior to the end of its lifetime.

**Cleaning Supplies**

The Linden Centre is working with local sources to develop eco-friendly cleaning products. As these products are developed, care should be taken to make sure that they are composed of natural plant extracts and not mineral oil extracts or harmful chemicals such as phosphates and Chlorine. Aside from the advantages to the environment that this development of eco-friendly cleaning products provides, developing the products at the local level promotes local business, manufacturing and employment, as well as reducing transportation costs and packaging costs through the use of bulk purchasing.\(^{32}\)

**Transportation**

**Site Specific Solutions**

There are efficiency actions that Linden Centre drivers/vehicle owners are already doing that can be inventoried as part of the Centre’s sustainability portfolio. One example is the encouragement of guests to travel in the community by foot, bicycle, or horse drawn cart. In addition there is public transportation connecting Xizhou to other communities. Also, the avoidance of single-occupant vehicles, which is the most inefficient form of motorized transportation is currently in practice at the Linden Centre. An easy win would be to make that information readily available to guests on the website and onsite.

As a next step reducing energy consumed in transportation of Linden Centre guests and employees will require coordination and collaboration among a variety of groups including: Linden Centre, drivers/vehicle owners, suppliers and/or employees responsible for pick up and transportation of guests and goods. There may also be cost efficiencies gained by coordinating at the community scale in order to meet goals for renewable transportation fuel usage. Linden Center representatives have voiced interest in using waste grease from cooking and/or other waste materials to produce biofuels for use by drivers employed by Linden Centre. There are many examples of successful similar projects, suggesting that this may be an achievable goal for the Linden Centre, though not without some cost in equipment, materials, and staff time. However, proper planning is required, particularly given the current reality for the Linden Centre of vehicles not being owned by the Centre. Others’ success should be considered and can be replicated to implement a successful homegrown fuel project and avoid potential pitfalls that reduce the performance of the vehicles or vehicle components. The Centre can either move forward with straight waste vegetable oil (WVO), though if larger quantities of fuel is desired, with minimal (but properly done) processing, WVO can be made into high-quality biofuels by blending with petroleum fuels and used in diesel vehicles. When properly done, WVO and

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\(^{32}\) “Greening the Broads,” Green Business UK/SEA LTD. [www.green-business.co.uk](http://www.green-business.co.uk)
biofuel blends operate very well, increase engine component life, and reduce maintenance costs.

Beyond biofuels, other fuels currently used by the Linden Centre, such as propane and natural gas, can be appropriate for transportation. Liquefied Petroleum Gas (LPG), commonly referred to as autogas or propane, can be used as motor fuel, as can compressed natural gas (CNG). Electricity can also power vehicles, as evidenced by the electric scooters currently in use in Dali. The benefits of these alternative fuels and advanced vehicle technologies include reduced reliance on imported fuels (depending on the sources of fuel available in Yunnan), and reduced greenhouse gas emissions. This reduced reliance on imported fuels can help stabilize fuel costs over time, assisting with accurate costing and budgeting for the Linden Centre. It is important to remember, though, that each technology has benefits and limitations that require appropriate application to be fuel-efficient. For example, passenger vehicles that are used in an urban or sub-urban setting with frequent stopping and starting are optimal for hybrid or dedicated electric powertrains. In a rural setting these vehicles are not fuel efficient, as much of the efficiency of electric drive is gained through regenerative braking that recharges the vehicle’s electric motor. Also, medium and heavy-duty vehicle fleet managers looking for a cleaner fuel than diesel would be best served through CNG, as opposed to electric drive, based on the relatively low cost of CNG fuel and CNG engine technology, energy content, and applicability for relatively long-distance, over-the-road (non-stop-and-go) driving patterns.

**Community Scale Solutions**

Due to economies of scale, transportation fuel costs can be better managed at a larger scale than a single vehicle fleet, or single vehicles, contracted by a private company (Linden Centre). As the Linden Centre considers sustainability priorities for transportation energy use, it may be beneficial to consider opportunities for collaboration at the community scale. This would be a medium- to long-term effort, given the increased complexity of projects involving multiple stakeholders, and the cost of a community scale biofuels effort. So called Bio Towns are cropping up around the world with the goal of producing their communities’ energy needs through biorenewable sources produced locally. In the rural City of Reynolds, Indiana, USA, for example, the community has been working since 2004 to implement a three-phase plan to become energy independent (for transportation and building energy needs). Largely focused on producing and using ethanol and biodiesel fuels for transportation, the city plan includes moving to sustainable sources of energy to heat and cool buildings (see Heating section for solutions appropriate for Linden Centre building heating/cooling needs). Cities in Ireland, Denmark, Japan, and other nations are also moving into resilient, or sustainable, energy planning. Some use the Transition Town model (developed in Ireland), which is founded on a concern over the impacts to economic health and quality of life from potential energy supply disruptions. Kinsale, where Transition Towns began, has focused on transportation planning at the community scale with a focus on “people, heritage, and landscape, rather than vehicles and

33 [http://www.in.gov/oed/2395.htm](http://www.in.gov/oed/2395.htm)
construction.\(^{34}\) One of the goals for Kinsale is improved bussing to and from key towns (Kinsale is a rural community), another is a biofuel station for public use. Of note, as well, is an effort between the People’s Republic of China and the Global Village Institute for Appropriate Technology to explore legal standards for “ecovillage” design.

### Waste

#### Site Specific Solutions

Hotels in the West offer examples of cost savings from working toward so called zero waste goals. While some of the cost savings described may seem modest, any cost reduction is a benefit to a business. A way to continue sustainability initiatives is to invest the savings from sustainability activities, such as zero waste actions, into an account used for additional sustainability actions. The Westin San Francisco Airport Hotel is saving $6000 annually through their waste control program, while the Thunderbird Hotel in Bloomington, Minnesota is saving over $300 per month through their food composting and food waste control practices.\(^{35}\) In this way, we see that composting, which Linden Centre has already begun, can be part of an effective waste management system.

Composting can be made more efficient if the process can be sped up. Certain catalysts, some basic, others complex, can increase the rate at which food scraps and yard waste can be turned into usable compost. On the relatively basic side, vermicomposting, or worm composting, uses composting bins, as opposed to an open compost heap, to contain worms in the compost material. Worms help speed up composting by digesting decomposing food and plant scraps, more quickly processing the scraps into “castings” usable as compost.

As noted in the waste water section, anaerobic digestion and other waste-to-energy technologies offer solutions for solid waste management. These technologies can meet site-specific needs or community-scale needs. A potential challenge is the cost of such technologies, though, with proper planning, they can fit well within Linden Center’s sustainability plan. Kinsale, Ireland, the Transition Town mentioned in the Transportation section of this paper, has planned a community-scale anaerobic digester. Reynolds, Indiana, USA is also utilizing this technology. Small-scale anaerobic digesters have been placed at homes near the Linden Center, to varying degrees of success. As an historic property concerned with the sight lines of its facilities, Linden Centre may find that working toward a community-scale waste-to-energy project is preferable to attempting to site a waste-to-energy system on site at the Centre. These technologies are improving each year, and it may serve the Centre well to track the progress of technology development as part of working toward waste-to-energy as a medium- or long-term sustainability objective for the Centre.

The organic content of solid waste has the ability to be converted into biogas that can serve a variety of energy needs. The process is known as anaerobic digestion and can be accomplished in small scale, such as on-site at the Linden Centre, or in larger scale such as at the Xizhou solid waste disposal dump. Anaerobic digestion is a natural, carbon-neutral process.

\(^{34}\) [http://www.transitiontowkinsale.org/projects/rural-transportation/56-traffic.html](http://www.transitiontowkinsale.org/projects/rural-transportation/56-traffic.html)

in which bacteria break down organic matter in the absence of oxygen to form biogas, comprised primarily of methane, and digestate. Organic inputs can include food waste, manure and sewage (blackwater), and the outputs can be used to supply biogas for on-site heating, cooking and electricity, and/or can be upgraded to renewable natural gas and used to power vehicles or augment the natural gas supply. Furthermore, the digestate, or remaining solids, can be composted and used for fertilizer.\textsuperscript{36}

Installation of digesters for domestic use is a major effort in rural China and is supported by variety of programs with a national target of 27 million installations by 2010, up from 9.8 million households in 2000. In addition to production of biogas for fuel, digesters provide basic sanitation services, thus achieving multiple environmental goals by improving rural sanitation, reduction of greenhouse gases by supplying more efficient natural gas, and improvement of respiratory health by reducing the burning of coal for heat and power.\textsuperscript{37}

\textsuperscript{36} Pew Center on Global Climate Change, 2011, \textit{Anaerobic Digesters}.
The decision to install an anaerobic digester system and what type and size of system to use depends on the volume, moisture content and type of waste available as feedstock. Furthermore, the production of biogas depends upon the following relevant factors:

- The methane production potential of the feedstock used
- The volume of waste and necessary processing time
- The capital and operating costs of the digester
- The intended use of the biogas produced
- The value of the compost produced as a byproduct of digestion

Certainly some digesters are more costly to construct and operate than others, and the amount and intended use of biogas capable of being produced may be a determining factor in whether the installation of such a system is cost-effective. However, the external benefits of operating a digester should also be taken into account, which may include mitigating the amount of waste disposal in dumps and landfills. Provided the Linden Centre or future Linden projects have space available on-site or nearby, and to the extent a system of one or more digesters can be integrated into the historic architecture of the property, it will then become a matter of evaluating the relevant factors to determine the feasibility and cost of installing such a system. Below is an example of a series of digesters installed in a commercial or institutional setting.

Source: Shenzhen Puxin Technology Co. LTD.

Community Scale Solutions

The rural village of Xizhou collects approximately four tons per day of solid waste per day, which it collects and deposits in a smoldering dump. Assuming comparisons can be drawn from studies of solid waste generation in other developing countries in Asia and other parts of China, typically biodegradable waste such as food and yard waste is the largest proportion by volume.
of municipal solid waste (MSW). The same holds true in rural areas. Indeed, in a study of rural solid waste (RSW) in a village in the Tailake Region of China (in Southeastern China), the average waste content comprised by volume was 41.1% food waste, 16.8% ceramics waste, 16.0% brick debris, and 13.3% plastic packaging, glass, metal, etc. Incineration of solid waste with this level of biodegradable content is not an optimal strategy for disposal of waste. Food and yard waste have high moisture content, and consequently a low calorific value, which is not conducive to self-sustaining incineration. As such, composting is seen as a more productive measure for dealing with the approximate half of RSW that is biodegradable. However, though composting has been effectively used in China for perhaps over 1,000 years, recent government policies (largely oriented toward big cities) have promoted incineration over composting due to more formalized waste management and centralized processing. This is because in China, as in many developing countries, household level waste separation (separation being necessary for composting) is uncommon, and the extra cost of centralized sorting is huge. With China’s modernization, the increase in non-biodegradable material within solid waste means that more hazardous materials are apt to be comingled within the solid waste, thus rendering the resulting compost potentially unfit for agriculture and other uses. Therefore, any initiative to improve the solid waste situation in Xizhou will require separation of solid waste materials at the household level.

In order to initiate an alternative strategy for dealing with Xizhou’s solid waste, the local villagers must be made aware of the problems associated with ineffective management of the solid waste, as well as buying into a strategy of separating solid wastes at the household level. Government, environmental organizations, NGO’s and other organizations (such as the Linden Centre) play a key role in bringing about this awareness, which in turn creates a sense of ownership among the population and an interest in participation in effecting solutions. The whole community must play a role.

In addition, the engagement of the informal sector of unregistered and unregulated scavengers, collectors, sweepers, etc., motivated by the sale of wastes, provides an opportunity to institutionalize this sector by providing organizational, technical and capacity building support to create entrepreneurial ventures focused on recycling and composting.

Furthermore, studies have indicated that rural village populations are very supportive of improving solid waste management practices in their communities. Close to home, in a study of households’ willingness to pay for solid waste collection and disposal conducted by the World Bank in four small towns in Eryuan County, Yunnan Province, approximately 70 km’s from Dali,

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39 C. Visvanathan and J. Trankler, 2003, Municipal Solid Waste Management in Asia: A Comparative Analysis, Environmental Engineering & Management School of Environment, Resources and Development, Asian Institute of Technology, Thailand

40 Production and Feature of Rural Solid Wastes in Tailake Region of China

41 Visvanathan 2003

43 Visvanathan 2003
44 Visvanathan 2003
it was determined that on average a household in Eryuan was willing to pay an average of approximately 17 yuan per month for such services. Even the poorest households in Eryuan, which have an annual income lower than 4,000 yuan and account for about 25% of the population, were willing to pay more than 5% of their income for solid waste disposal.\textsuperscript{45} If the Eryuan example can be taken to exemplify Xizhou, then there should be a groundswell of support and potential willingness to pay for improving Xizhou’s handling of solid waste. Furthermore, the 17 yuan per household per month was just enough to cover the cost of a proposed solid waste system contemplated for funding by the World Bank.\textsuperscript{46}

In this regard, and on a larger scale, the state-owned Yunnan Metropolitan Construction Investment Company (YMCI), established a subsidiary, the Yunnan Circular Economy Investment Company (YCEI) in August 2010. Reflecting the national policy for the “rapid development of new strategic industries and circular economy,” as well as the Yunnan provincial government’s goal in building a strong “green economy,” among YMCI’s core businesses are included Yunnan Water Investment Company, LTD, which specializes in water and waste water industries and YCEI which focuses on green industries, urban and rural solid waste management, and the circular economy. YCEI has assembled a team of domestic and foreign educated experts and either acquired or entered into joint ventures with various domestic and international firms specializing in solid waste handling and recovery. According to YCEI, they have developed a “resource reutilization” system for MSW that handles 100 – 300 tons per day that produces “hazard-free” (no heavy metals), completely sanitized products economically and with no secondary contamination, e.g. no discharge of industrial wastewater. While 100 – 300 tons of solid waste per day greatly exceeds that produced by Xizhou, perhaps an initiative involving Xizhou and its neighboring communities would be of sufficient scale to attract the investment of companies like YCEI.\textsuperscript{47}

\textsuperscript{46} World Bank 2011
\textsuperscript{47} Yunnan Circular Economy Investment Company, LTD. (YCEI). PowerPoint Presentation by Yunnan Circular Economy Investment Company, LTD.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Current Best Practices</th>
<th>1 year goals (0 - $)</th>
<th>Stretch Goals ($ - $$$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>general electricity use</td>
<td>minimal entertainment appliances (e.g. televisions)</td>
<td>ensure staff awareness of best practices</td>
<td>install room card-key switches or wireless occupancy sensors</td>
</tr>
<tr>
<td></td>
<td>line drying of laundry</td>
<td></td>
<td>install digital dashboard so guest get realtime feedback on energy consumption</td>
</tr>
<tr>
<td><strong>Building</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>building rehabilitation &amp;</td>
<td>building rehabilitation holds conserves natural resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stewardship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traditional architecture</td>
<td>walls shelter from wind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>comfort conditioning</td>
<td>infrequent targeted use of local radiant heating sources is efficient</td>
<td></td>
<td>consider geothermal radiant comfort heating - geothermal source</td>
</tr>
<tr>
<td>lighting</td>
<td>glass-roofed dining room is passively heated</td>
<td>install controllable shading to reduce unwanted solar gain</td>
<td>consider geothermal systems in future locations for heating, cooling, and water heating</td>
</tr>
<tr>
<td>water heating</td>
<td>energy efficient compact fluorescent and LED lighting sources</td>
<td>improve effectiveness of artificial lighting by reducing glare</td>
<td></td>
</tr>
<tr>
<td></td>
<td>some photovoltaic light sources</td>
<td>conceal or diffuse lighting sources - reduced glare enhances effectiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>use of natural light</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>glass-roofed dining room is naturally lit</td>
<td>install glare-reducing controllable shading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>solar thermal for kitchen use</td>
<td>adjust temperature settings to optimal efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>limited daily hours for hot water</td>
<td></td>
<td>underfloor comfort heating in bathrooms would shorten shower times</td>
</tr>
<tr>
<td></td>
<td>insulated hot water storage tank and lines in the mechanical room</td>
<td>insulate hot water piping where accessible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>monitoring of hot water tank temperature</td>
<td>consider installing water flow restrictors and low-flow toilets where feasible</td>
<td>install water flow restrictors, low-flow shower heads, efficient dishwashers</td>
</tr>
<tr>
<td>Alternative/Renewable Energy</td>
<td></td>
<td></td>
<td>Solar thermal, solar photovoltaic, and wind energy for future locations</td>
</tr>
<tr>
<td>Cooking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cooking</td>
<td>scheduled cooking and dining times conserves energy</td>
<td>implement optimal maintenance policies for fixtures and equipment</td>
<td>make energy efficiency a priority as equipment is replaced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>replace pilot-lit equipment with electronic ignitors</td>
<td></td>
</tr>
<tr>
<td>refrigeration</td>
<td></td>
<td>adjust temperature settings to optimal efficiency</td>
<td>make energy efficiency a priority as equipment is replaced</td>
</tr>
<tr>
<td>Activity</td>
<td>Current Best Practices</td>
<td>1 year goals (0 - $)</td>
<td>Stretch Goals ($ - $$$)</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>local foods</td>
<td>local foods used in meals cooked for guests and staff</td>
<td>identify where ingredients in guest meals are produced</td>
<td>work with local farmers to adopt more sustainable farming practices</td>
</tr>
<tr>
<td>Cleaning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laundry</td>
<td>cold-water laundering</td>
<td>optimize soap formulation for cold water use</td>
<td>install more efficient laundry equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>specify water saving benefits in terms of Xizhou villagers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>devise strategy to reduce rinse cycles</td>
<td></td>
</tr>
<tr>
<td>Cleaning supplies</td>
<td>self-produced eco-friendly cleaning products support local enterprise and reduce transportation and packaging impacts</td>
<td></td>
<td>Future opportunity for branding of Linden Centre cleaning products</td>
</tr>
<tr>
<td>Transportation</td>
<td>limited single-occupant vehicle use</td>
<td>promote public transportation options for longer trips</td>
<td>explore alternative fuel use</td>
</tr>
<tr>
<td></td>
<td>availability of buses to neighboring towns</td>
<td>coordinate mass transit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>non-motorized transport usage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycling</td>
<td>collecting and redeeming plastic water bottles for 0.5 rmb per bottle</td>
<td></td>
<td>facilitate community recycling program for non-biodegradable and composting or bio-fuel conversion of biodegradable solid waste</td>
</tr>
<tr>
<td>Guest Engagement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activities</td>
<td>walking &amp; biking</td>
<td>include energy efficiency goals and actions on website</td>
<td>include informational packet and facility tour highlighting resource efficient technologies and practices</td>
</tr>
<tr>
<td>Local awareness</td>
<td>Xizhou engagement builds understanding</td>
<td>include energy efficiency goals and actions in onsite signage</td>
<td>create new guest program engaging in an existing resource efficient practice in Xizhou</td>
</tr>
<tr>
<td></td>
<td>understand and demonstrate energy efficiency benefits of traditional and contemporary architecture</td>
<td>highlight traditional and new energy efficiency practices within Xizhou village, Dali, and Yunnan province</td>
<td></td>
</tr>
<tr>
<td></td>
<td>highlighting of local foods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>linen exchange policy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Additional Information:

Additional Information Item “A”: Diesel Dynamo (Generator) Fuel Consumption Chart

Approximate Fuel Consumption Chart

This chart approximates the fuel consumption of a diesel generator based on the size of the generator and the load at which the generator is operating at. Please note that this table is intended to be used as an estimate of how much fuel a generator uses during operation and is not an exact representation due to various factors that can increase or decrease the amount of fuel consumed.

<table>
<thead>
<tr>
<th>Generator Size (kW)</th>
<th>1/4 Load (gal/hr)</th>
<th>1/2 Load (gal/hr)</th>
<th>3/4 Load (gal/hr)</th>
<th>Full Load (gal/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.6</td>
<td>0.9</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>30</td>
<td>1.3</td>
<td>1.8</td>
<td>2.4</td>
<td>2.9</td>
</tr>
<tr>
<td>40</td>
<td>1.6</td>
<td>2.3</td>
<td>3.2</td>
<td>4.0</td>
</tr>
<tr>
<td>60</td>
<td>1.8</td>
<td>2.9</td>
<td>3.8</td>
<td>4.8</td>
</tr>
<tr>
<td>75</td>
<td>2.4</td>
<td>3.4</td>
<td>4.6</td>
<td>6.1</td>
</tr>
<tr>
<td>100</td>
<td>2.6</td>
<td>4.1</td>
<td>5.8</td>
<td>7.4</td>
</tr>
<tr>
<td>125</td>
<td>3.1</td>
<td>5.0</td>
<td>7.1</td>
<td>9.1</td>
</tr>
<tr>
<td>135</td>
<td>3.3</td>
<td>5.4</td>
<td>7.6</td>
<td>9.8</td>
</tr>
<tr>
<td>150</td>
<td>3.6</td>
<td>5.9</td>
<td>8.4</td>
<td>10.9</td>
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<tr>
<td>175</td>
<td>4.1</td>
<td>6.8</td>
<td>9.7</td>
<td>12.7</td>
</tr>
<tr>
<td>200</td>
<td>4.7</td>
<td>7.7</td>
<td>11.0</td>
<td>14.4</td>
</tr>
<tr>
<td>230</td>
<td>5.3</td>
<td>8.8</td>
<td>12.5</td>
<td>15.6</td>
</tr>
<tr>
<td>250</td>
<td>5.7</td>
<td>9.5</td>
<td>13.6</td>
<td>16.0</td>
</tr>
<tr>
<td>300</td>
<td>6.8</td>
<td>11.3</td>
<td>16.1</td>
<td>21.5</td>
</tr>
<tr>
<td>350</td>
<td>7.9</td>
<td>13.1</td>
<td>18.7</td>
<td>25.1</td>
</tr>
<tr>
<td>400</td>
<td>8.9</td>
<td>14.9</td>
<td>21.3</td>
<td>28.6</td>
</tr>
<tr>
<td>500</td>
<td>11.0</td>
<td>18.5</td>
<td>26.4</td>
<td>35.7</td>
</tr>
<tr>
<td>600</td>
<td>13.2</td>
<td>22.0</td>
<td>31.5</td>
<td>42.8</td>
</tr>
<tr>
<td>750</td>
<td>16.3</td>
<td>27.4</td>
<td>39.3</td>
<td>53.4</td>
</tr>
<tr>
<td>1000</td>
<td>21.6</td>
<td>36.4</td>
<td>52.1</td>
<td>71.1</td>
</tr>
<tr>
<td>1250</td>
<td>26.9</td>
<td>45.3</td>
<td>65.0</td>
<td>88.8</td>
</tr>
<tr>
<td>1500</td>
<td>32.2</td>
<td>54.3</td>
<td>77.8</td>
<td>106.5</td>
</tr>
<tr>
<td>1750</td>
<td>37.5</td>
<td>63.2</td>
<td>90.7</td>
<td>124.2</td>
</tr>
<tr>
<td>2000</td>
<td>42.8</td>
<td>72.2</td>
<td>103.5</td>
<td>141.9</td>
</tr>
<tr>
<td>2250</td>
<td>48.1</td>
<td>81.1</td>
<td>116.4</td>
<td>159.6</td>
</tr>
</tbody>
</table>
Additional Information Item “B”: Washing Machine Specifications and Consumption Calculations

Details:
1 Clothes Washer Load:
  ● 1 cycle with soap
  ● 3 rinse cycles
  ● extractor cycle

Specifications:
Drum: 42”L x 24”D x 24”H = 14 cubic feet

Calculations:
  ● Estimated one wash cycle requires 1/2 of the washing machines volume of water=104 gallons/2= 52.3 gallons per cycle
  ● 4 cycles per wash load: 52.3gallons x 4= 209.5 gallons converted to cubic meters = 0.729m³
  ● 0.729m³ translates to 0.7% of the 100m³ tank consumed per load

Summary:
The staff member we interviewed regarding laundry with MCK estimated that the Virginia Tech XMNR departure would yield three loads of laundry (towels and bed linens). Based upon the calculations above, three loads of laundry consumes 2.3% of the storage tank. The following website contains commercial clothes washer consumption data based on size of washer and may be helpful for comparison to the Linden Centre’s current machine.
### Additional Information Item “C”: Savings of Hot Water Heater by Type

<table>
<thead>
<tr>
<th>Water heater Type</th>
<th>Efficiency (EF)</th>
<th>Installed Cost</th>
<th>Yearly Energy Cost*</th>
<th>Life (years)</th>
<th>Total Cost (Over 13 Years)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional gas storage</td>
<td>0.6</td>
<td>$850</td>
<td>$350</td>
<td>13</td>
<td>$5,394</td>
</tr>
<tr>
<td>High-efficiency gas storage</td>
<td>0.65</td>
<td>$1,025</td>
<td>$323</td>
<td>13</td>
<td>$5,220</td>
</tr>
<tr>
<td>Condensing gas storage</td>
<td>0.86</td>
<td>$2,300</td>
<td>$244</td>
<td>13</td>
<td>$5,170</td>
</tr>
<tr>
<td>Conventional oil-fired storage</td>
<td>0.55</td>
<td>$1,400</td>
<td>$654</td>
<td>8</td>
<td>$11,299</td>
</tr>
<tr>
<td>Minimum Efficiency electric storage</td>
<td>0.9</td>
<td>$750</td>
<td>$463</td>
<td>13</td>
<td>$6,769</td>
</tr>
<tr>
<td>High-eff. electric storage</td>
<td>0.96</td>
<td>$820</td>
<td>$439</td>
<td>13</td>
<td>$6,520</td>
</tr>
<tr>
<td>Demand gas (no pilot) 4</td>
<td>0.82</td>
<td>$1,800</td>
<td>$256</td>
<td>13</td>
<td>$4,915</td>
</tr>
<tr>
<td>Electric heat pump water heater</td>
<td>2.2</td>
<td>$1,560</td>
<td>$190</td>
<td>13</td>
<td>$4,125</td>
</tr>
<tr>
<td>Solar with electric back-up</td>
<td>1.2</td>
<td>$4,300</td>
<td>$175</td>
<td>13</td>
<td>$7,072</td>
</tr>
</tbody>
</table>

1. Purchase costs include our best estimates of installation labor and do not include financial incentives.

2. Operating cost based on hot water needs for typical family of four and energy costs of $0.50/kWh for electricity, $1.40/therm for gas, $2.40/gallon for oil.

3. Life expectancy for water heaters is highly variable, largely dependent on water hardness, and on maintenance.

4. Future operating costs are neither discounted nor adjusted for inflation.

5. Currently, there is too little data to accurately estimate life expectancy for tankless water heaters, but preliminary data shows that tankless water heaters could last up to 20 years. For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance (ACEEE, 2012).