



Sustainable Redevelopment for 93 Grand

An Interdisciplinary Qualifying Project
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Abstract

This report, which was prepared for the Main South Community Development Corporation, will look at possible ways to redevelop the abandoned Crompton and Knowles Loom Works building into a sustainable building within the Main South community. Through research into the community, the building and modern green technologies we were able to identify valuable information and various sustainable technologies that could provide a starting point for Main South CDC's renovation project.

Executive Summary

Years ago the Main South community was heavily influenced by the Crompton and Knowles Loom Manufacturing Corporation and was a proud community. As of 1986 the Main South Community Development Corporation has undertaken various projects in the area in an attempt to revitalize the area, while incorporating sustainable development practices. The Main South CDC has recently acquired part of the Crompton and Knowles complex and now has the opportunity to renovate the building to have a positive impact on the declining community.

Our project was to research and recommend various methods which would assist Main South in sustainably redeveloping 93 Grand into building that will benefit the community. Since the redevelopment project for 93 Grand was in its beginning stages, our project had various aspects which we were able to break into three categories: Community, Building Information, and finally Technology. Our building was once something that the neighborhood was not only proud of but also something that benefited the community. With the global increase of fossil fuel dependence building sustainably is a must. Our project will be to gather building information and research the feasibility of modern green technologies that will promote the welfare of the surrounding community.

Our project included several goals. Our objectives in the community aspect of our project primarily involved gathering research involving the demographics of the area, information regarding the current housing market of the region, as well as gaining a better sense of the community itself. First our group developed a community map of every business within the community. We, then, researched Main South's demographics, housing situation, and finally the feasibility of incorporating a green childcare center in the 93 Grand project. The first objective of our building information section was to gathering all possible documentation regarding the buildings floor plans, soil charts and sewer maps. The other goals within this section were to locate and identify all local green suppliers as well as identifying and categorizing all green building materials into price point build-outs. Finally, goals for the technology section of our project was to conduct feasibility studies concerning the possibility of incorporating modern green technologies in the renovation of the Crompton and Knowles Loom Works building.

We used various methods in order to accomplish the different goals we developed for our project. In order to create our community map we toured the entire area our sponsor had identified as our community on foot recording the location and information of every business we passed. After gathering the information we created an aerial view map which provided the location of all the business while categorizing them by the service each would provide to the community. The methods for the other aspects of our community section, including the demographic information, housing information, and green childcare studies, all relied heavily on research and data collection. We collected our demographic information from the 1999 U.S. Census. In order to identify housing information, we used the information available in the U.S. Census, while also calling apartment and condominium complexes in the area requesting information. To gather information about a possible green childcare center we located several case studies, provided a checklist provided by the Oregon Environmental Council as well as locating local green child care centers.

In order to gather information about the building we first had to locate it. We started by visiting City Hall, where we were directed to the Department of Public Works. We then visited the Worcester Public Library where we were able to find soil maps and information for the area which we photocopied. We then contacted the DPW who provided our group with sewer maps for the building and surrounding area. In order to attain floor plans for the building we relied upon our sponsor, who provided us with several useful sets of blueprints. As for the goal of indentifying local suppliers, we started by searching for companies and retailers in the area who advertised green materials. Upon identifying these suppliers, we further researched them regarding what materials the supplied and their current location. We organized these suppliers into an organized list containing all contact information, as well as a short summary of each supplier. We also provided a map to show the location of each supplier. Finally, to create price point build-outs we started by identifying and researching modern green materials and their prices. From here we separated all the materials based upon price and how green the materials are into categories entitled +1, +2, and +3, with the greenest and most expensive materials in the +3 category and cheaper materials in the +1 category.

The methods we used for our technology section began with our literature review section in which we researched all applicable green technologies which could potentially be incorporated

into our building. Following our literature review we were able to narrow the number of technologies we recognized as still being feasible. To further our feasibility studies we started contacting local professionals who could provide us with an educated analysis of our individual project. We understood that professionals could give us information pertaining to our particular project type and climate that we likely could not find through research and case studies.

The main results of work in the community can be seen through our community map, our demographic data tables and graphs, community housing information and our green child care information. The community map identifies local businesses in an attempt to promote the local economy, while giving the Main South CDC a better understanding of which types of businesses to incorporate into their mixed-use building. After identifying demographic data and organizing it into graphs we were able to identify the dominating culture of the area as well as other possible trends. Through our housing information collection our group created graphs which allowed us to show that the overwhelming majority of citizens living in Main South are currently renting, and not owning, with only 40% of the current population being housed.

Our building information results include several blueprints, soil maps, and sewer maps of the area which have been condensed into a binder which provides for easy access to our results for our sponsor. Other results in this section include the list of local green suppliers, as well as a summary of their company, the materials which they can supply, as well as a map providing their location. The results of our price point build-outs are shown by organizing all green building materials into categories such as countertops, cabinetry, and flooring. From here we formed a +1, +2 and +3 list selecting materials from each category and put them into each numbered build out with the greenest and most expensive materials going to the +3 build-out and the less expensive going to the +1 build-out.

The results we found from our technology section concluded which technologies were feasible for this type of refurbishment project. In order to come to these conclusions we had to look at the cost benefit of each technology, as well as whether they are applicable to this type of project, climate and building. The technology we identified as being feasible after going through our methods were geothermal heating, photovoltaic systems, a rooftop garden and a stormwater management system.

The community is in need of housing and we believe that the two largest buildings in the complex are perfect for renovation to become affordable housing. Also in the hopes of making this community more sustainable this building should use several green technologies. The technology that will be most easily integrated into the building is photovoltaics because of the huge unobstructed roof space in the two largest buildings. Another technology that must be incorporated is geothermal heat because not only is the surrounding ground suited for this type of system but also, it will greatly decrease the carbon footprint of the building while decreasing the utility bills for the residents which makes living in the building more affordable. As far as water alternatives go we should install localized AQUAS systems for grey water filtration because a large centralized system would be too expensive. Also if possible a green roof should be incorporated to not only reduce storm water runoff from the building, but also add insulation to the building's roof. Lastly we believe that buildings 28, 28A should be torn down so that either parking or garden space can be created.

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Chapter 1: Introduction

Recently the world's population has been faced with a growing problem involving global warming and an overuse of our natural resources. Climate change is a well known problem mostly caused by the amount of greenhouse gas emissions and is felt by many in our world today. The effects of global warming can be seen in the melting of glaciers and ice caps throughout our oceans. Countries around the world are discussing how and what they can do to lower the CO₂ emissions; 40% of which are caused by public electricity and heat (Abhari, 2008). One step to solving this problem is to slowly phase sustainable development and green technologies into our everyday lives. The world is in need of buildings that can sustain themselves by using environmentally friendly energies, and reserve our natural resources for generations to come. The definition of green building is

“the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction” (Green Building, 2008).

Traditional buildings produce waste and pollution because society as a whole tends to take energy use for granted without thinking about the negative consequences of overusing energy and resources.

Building green is beneficial to the environment, the economy, and our health. With superior design techniques, green buildings offer benefits ranging from better overall air quality to natural lighting. Furthermore, it minimizes the use of resources and decreases the amount of harmful air emissions into our environment (Benefits of Green Design, 2009). Building green makes it possible for us to use renewable resources such as solar and geothermal energy instead of the non-renewable resources of fossil fuels and fresh water.

Although the initial costs for sustainable design may be higher than traditional building materials, they can reduce operating costs substantially (Jankiewicz & Stooover, 2007). The cost associated with green building includes the need for more design time, as well as higher modeling costs. Since existing buildings are constructed to older standards, applying modern green building technologies can create other implementation problems. Green building, however, is an investment that will not only assist individual companies and homeowners, but will also help ensure availability of resources for future generations.

Urban areas are the primary source of the climate change dilemma. With so many residents filling cities to their capacity, there is a tremendous amount of energy used daily. Furthermore, with most cities not producing electricity and heat through green resources, they emit substantial amounts of green house gasses into the air every day, driving the environmental change. In 1950 the world urban population was 29%, growing to 37.2% in 1975. As of 2008 the percentage of world urban population exceeded 50% (World Urbanization Prospects: 2005 Revision, 2005). With this vast increase of urbanization throughout the years, it is clear that if green technology is not taken into consideration, the amount of greenhouse gasses that are discharged into the air every day is only going to continue to increase. Cities need to take action against this rising problem now, and that action is sustainable development. “Cities themselves present both the problems and solutions to sustainability challenges of an increasingly urbanized world” (Grimm, 2008).

The Crompton Knowles Loom Manufacturing building, in Worcester Massachusetts, was built in 1897 and is a good example of these types of problems. Now an abandoned factory, the building at 93 Grand Street holds seemingly endless possibilities in green restoration and sustainable development. As Worcester Polytechnic Institute students, we were invited to work with our sponsor Peggy Middaugh on the renovation project at the Worcester Community Project Center. The Main South Community Development Corporation (CDC) owns the building while Ms. Middaugh is the primary coordinator for the building development. We worked with Ms. Middaugh to conduct feasibility studies of several specific green technologies that appeared to be applicable to the Crompton Knowles building from the design charrettes. Furthermore, we researched ways to incorporate sustainable development and green infrastructure into the life of the building. These studies will ultimately provide the CDC with a concise and complete report of green technologies that are the most viable options.

The technologies that were researched include many “green” ways to provide the building with heat, electricity and efficient water use. More specifically, we researched the potential for installing a geothermal system, solar hot water and photovoltaic cells. To provide efficient water use we investigated the possibility of a rooftop garden, grey water and storm water. After researching available technologies we conducted a feasibility study on each, using expert opinions and research we collected over the course of our project. We have also

considered possible ways to integrate the community into the Crompton Knowles renovation project, not only with the design but the actual implementations to the building as well.

Our report begins with a background chapter reviewing the history of the Worcester community and the Main South Community Development Corporation. The report then delves into the history of the Crompton Knowles Manufacturing complex and more specifically the buildings at 93 Grand that will be renovated. Furthermore, we have provided a section that covers the background of the technologies we have examined, including their history and environmental benefits. We will conclude our background and literature review section with a brief overview of the LEED certification system and what makes a sustainable community.

Following the background chapter we describe the methods we used to gather the necessary information for this project in Chapter 3. In Chapter 4 the results of our methods are presented and the subsequent chapter is a discussion of these results and our recommendations for the Main South CDC.

Chapter 2: Literature Review and Background

In this chapter we will be providing historical background on the Worcester community, the Main South CDC and the Crompton Knowles Loom Manufacturing building. We will also be covering green technologies that the CDC has asked us to investigate. A rooftop garden will be researched followed by a brief introduction of LEED, with an explanation of their point system. The community is a very important aspect of this problem, therefore we will end with how a to develop a sustainable community.

2.1 “City of Seven Hills”

Worcester gets its nick name from the belief that it sits on top of seven hills: Pakachoag (Mount St. James), Sagatabscot (Union Hill), Hancock Hill, Chandler Hill, Green Hill, Bancroft Hill and Newton Hill (Worcester Historical Museum). Founded in 1722, Worcester is the 3rd largest city in New England and also known as “The Heart of the Commonwealth” (Worcester, 2009). Worcester in captures the feeling of a small town yet the convenience of a city. It has some interesting firsts;

- First to host the first national Women’s Rights Convention in 1850
- First radio station to ever play a Beatles song
- First ballpoint pen and typewriter were invented here
- First women to serve on the President’s cabinet was from Worcester
- First launching of the first liquid fuel rocket

Worcester is the home of many colleges, Anna Maria College, Assumption College, Becker College, Clark University, College of Holy Cross, Quinsigamond Community College, Umass Medical School, Worcester State College, and of course Worcester Polytechnic Institute (Worcester, 2009). There is also a public library, the DCU Center and a regional airport in the area. Most importantly, the Main South Community Development Corporation is located in Worcester, Massachusetts, improving the quality of life for many residents in the area (Main South CDC, 2009).

Today, Worcester is cleaning up its environment with a Brownfield Clean-up Revolving Loan Fund (BCRLF), which is funding the cleanup of the Crompton Knowles building. The mission statement for this loan is “To reclaim abandoned and underutilized brownfield sites for

productive reuse, provide additional job opportunities, increase the tax base, improve the quality of life for residents in surrounding neighborhoods, maximize leveraging opportunities from both the private and public sectors, and promote the program to private developers, lending institutions, the real estate community, and the non-profit sector” (Worcester Mass, 2009).

2.2 Main South Community Development Center

The Main South CDC is a non-profit organization incorporated in 1986. It was developed the help overcome problems within the community, and the increasing shortage of affordable housing (Main South CDC, 2009). The mission statement of the Main South CDC

“ is to improve the quality of life for ourselves, our families, and our neighbors by working together on projects and issues that will maintain and/or create safe affordable housing, support economic opportunities for businesses and residents of Main South, enhance the physical image of the area, and instill a sense of neighborhood pride and commitment.”

This organization has very realistic and necessary goals, which includes maintaining and developing safe and affordable house to the community along with the hopes of expanding rental and ownership opportunities. They also plan to enhance the physical image, inspire neighborhood pride and social cohesiveness (Main South CDC, 2009).

Due to the increasing number of foreclosed properties, the Housing and Economic Recovery Act of 2008 was set in place and the federal government has allocated funds under the Neighborhood Stabilization Program. Main South has taken an interest in this program, which redevelops foreclosed properties. Currently the CDC is also responsible for 1 Wyman Street which inhabits two commercial units and six residential units. This project is funded by the Neighborhood Revitalization Strategy Area and is employing a local labor force which will help stimulate economic growth.

Another project on the agenda for the CDC, is the YouthBuild Program on 189 Beacon Street. The Main South CDC will be working with YouthBuild Worcester to renovate this single family home into a 16 unit residential building. The YouthBuild program is set up to help individuals between the ages of 16 and 24 who grew up in low income households. Its focus is to help youth with educational and career skills, G.E.D assistance and provide them with the

knowledge that will help bring them employment in the future. Like the Crompton Knowles building, 189 Beacon Street is focusing on sustainable construction, by reusing as many materials as possible (Main South CDC, 2009). Lastly, their final project is now underway is at 93 Grand Street, the Crompton Knowles Loom Manufacturing Building. With a grant from the U.S Environmental Protection Agency, they have begun to cleanup this brownfield site. Our project will involve planning what this building will become, including evaluating the possibility of residential, commercial and/or retail space.

With all of these projects in line, the Main South CDC is providing the community with a courageous and inspiring attitude. They are helping the less fortunate with opportunities they may not have had under different circumstances. Not only are these individuals working to better themselves but they are giving back to the community as the same time. The Main South CDC is encouraging economic growth and is also giving back to their community.

2.3 The Crompton Knowles Complex

The Crompton Knowles Loom Manufacturing Complex is a very old, barren set of buildings which were built in an era when “green technology” did not exist. The Crompton and Knowles Loom Works was a loom manufacturing company created in 1897 by the merger of George Crompton and LJ and FB Knowles companies. The company found success creating and selling looms that manufacture textile fabrics (Worcester Mass, 2009). By World War II Crompton Knowles Loom Works had become one of the largest manufacturers of textile machinery in the world; however by the 1960’s the company started to turn towards other enterprises. Crompton and Knowles continued manufacturing textile weaving machines until it completely shut down all textile loom manufacturing by 1981. The company ultimately changed its name in 1990 to the Crompton Corporation and as of 2005 the Crompton Corporation merged with Chemtura, a chemical company that has a several billion dollar yearly revenue. (The Chemtura Corporation, 2006)

Much like a college campus, the buildings of the Crompton and Knowles manufacturing company are centered in the Main south community. In particular the buildings that we are considering are in a 200 by 250 foot lot containing 5 buildings. Like other buildings of its time, the Crompton Knowles Loom is very inefficient in its use of fossil fuel heat, electricity and water, and the actual quality of its current electrical, heating and water use (Places) Being that

the complex was built in the early twentieth century, lead and asbestos was present in the building. In the last 6 years this brown field site has been cleaned up. Essentially the insides of the buildings have been stripped out and disposed of properly. The two largest buildings, number 1 and 2 are both 5 floor buildings that have a brick exterior and have heavy timber construction. This building is in the center of a changing community the renovation of this building will be a catalyst to major positive changes.

2.4 Greening Technology

Green technology is any technology pertaining to use or production of energy that is done in environmentally friendly ways. These technologies are made to preserve our natural resources and give us a healthy environment to live in. The heart of green technologies is sustainable development. Sustainable development is any building that can be managed over time without damaging the environment, which includes green technology. Another important aspect of sustainable development is a “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (Craven, 2009).

2.5 Heating Alternatives

There are many ways to heat a building without causing harm to the environment. In this section we will be covering three different types of heating alternatives. The first is Geothermal heating. There are many different kinds of geothermal heating, which will be covered within this section along with solar heating and biomass heating. These technologies are relatively new but are found to be more efficient than traditional heating and most importantly, more environmentally friendly.

2.5.1 Geothermal Heating

Geothermal heat is widely used as a renewable resource due to the use of heat from within the earth’s core. A renewable resource is a resource that cannot be depleted much like how the wind will always blow no matter how much we try to stop it and how the sun will continue to shine no matter how much we put in front of it. The heat that is within the earth’s core is vast and some believe that it will take 10^9 years to exhaust this natural resource, thus making it a renewable resource (Rybach & Mongillo, 2006). There are two different types of geothermal energy, low temperature and high temperature. The high temperature type is mainly

used for electrical energy while the low temperature type is normally what is used for heating buildings, which is what the focus will be on in this section (Teodoriu & Falcone, 2008). Geothermal technology is used by many countries around the world and was first seen as far back as the 14th Century in Chaude Aigues, France (Ozgener, Hepbasli, & Dincer, 2007). The first successful experiment using geothermal energy was in Italy in 1904 by Prine Piero Ginori Conti. This was taken place in Larderello and now it provides the world with 10% of its geothermal electricity (Teodoriu & Falcone, 2008). In the 1960's the first large geothermal generating plant was seen in the United States at the Geysers in Sonoma Country in California (Teodoriu & Falcone, 2008). In the present day, geothermal energy has been successfully applied, both residentially and commercially in the USA, France, Romania, Canada, Italy, Iceland, Japan, New Zealand, China and Turkey (Ozgener, Hepbasli, & Dincer, 2007).

Geothermal has many advantages, including the fact that it supplies sustainable energy and has constant reliability, along with economic development and air quality. The most significant benefit of geothermal energy is the extremely low air emissions. Currently the amount of harmful air pollutions avoided by using a geothermal generation in comparison to traditional coal facilities, saves us from an average of 32,000 tons of nitrogen oxides, 78,000 tons of sulfur oxides, 17,000 tons of particulate matter, and 16 million tons of carbon dioxide per year (Kagel & Garwell, 2005).

Geothermal energy uses the heat from the earth to provide heat in your home. Heat within the Earth's core is always flowing outward and sometimes escapes through volcanoes in the form of lava, but is normally found under the Earth's crust. When the heat is confined underground it is continuously heating nearby rocks and water, this is where we can find geothermal energy. When the water is heated underneath the earth's crust, the water and steam can be trapped in permeable and porous rock, which is known as a geothermal reservoir (Blodgett & Slack, 2009).

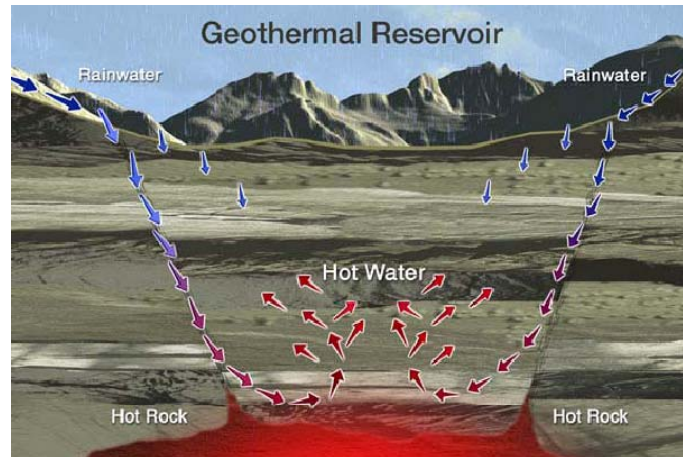


Figure 1. Geothermal Reservoir (Blodgett & Slack, 2009)

A geothermal reservoir is not always formed, but this doesn't put an end to geothermal energy. Geothermal heat pumps make geothermal heating available nearly everywhere in the world because they don't require the need of a reservoir (Blodgett & Slack, 2009). Heat pumps, also known as a geoexchange system, provide a heating and cooling system by drilling injection wells down under the Earth's crust. Within these wells are pipes that continuously loop water from the building down into the earth, heating the water up and then the hot water is sent back into the home where it will provide heat. During the summer, the same system is intact except that the hot water is pumped down into the ground to cool off and then is sent back into the building (Office, 2001).

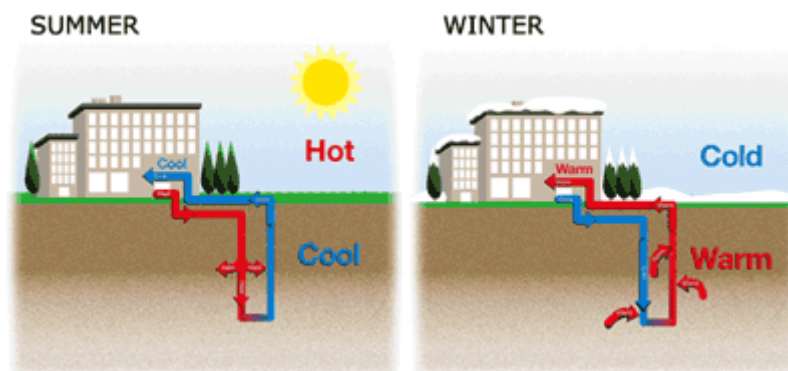


Figure 2. Geothermal Heat Pumps (Closed Loop Vertical System) (Geothermal HVAC, 2009)

There are also many three different types of geothermal heat pump systems; there are closed loop, open loop and lake or pond loop heat pumps. A closed loop system means that the water (or other liquid) is pumped down into the ground and after being heated or cooled off is looped back into the building. There are also three different types of closed loop systems: horizontal, vertical and slinky loops. A horizontal closed loop system is 400 to 600 feet long for each ton of heating or cooling needed. They are also the easiest to dig because they are not as far down into the ground as a vertical system, but can only be implemented if there is a large yard. When there is not a large yard available, vertical loops are best to use. These wells are 150 to 450 feet deep and require less piping than horizontal loops, unfortunately they are more expensive than the horizontal system (Consumer Energy Center, 2006). A closed loop vertical system can be seen in Figure 2.

As for an open looped system, the water is taken from a well for heating or cooling and after the water is used is returned to a drainage field or a second well (Geothermal Heat Pumps, 2001-2008). If the building is near a small pond or lake, the best system to install would be the lake or pond loop heat pumps. This type of system is much like the closed loop system however, for an indirect system the loops are usually slinky and lie in the pond or lake (Consumer Energy Center, 2006). For a direct lake or pond loop system, the water is taken directly from the body of water and after it is used, the water is shipped back into the pond or lake.

GEOTHERMAL HEAT PUMPS (GHP) a.k.a. Ground Source Heat Pumps (GSHP)

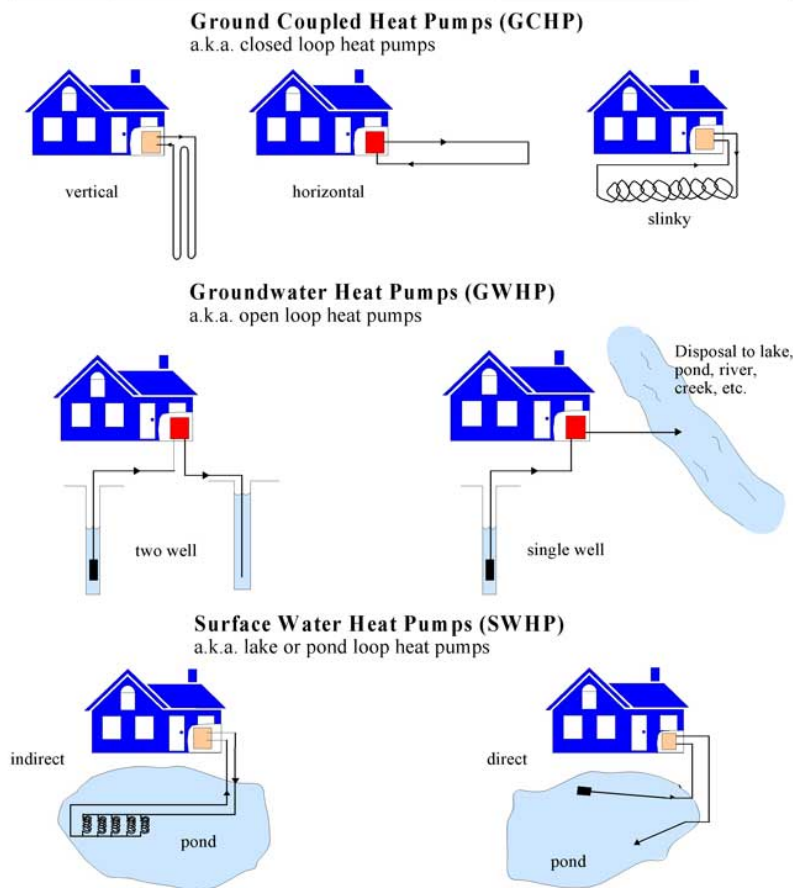


Figure 3. Different Type of Geothermal Heat Pumps (alt.energy, 2008)

A Geothermal system has also been used to develop electricity. When developing electricity, the water from within the wells is put through a steam separator where the steam is transferred into a turbine, which in turn powers a generator (Kagel & Garwell, 2005). In the geothermal plant in California, they used what is called dry steam. This is the same process as mentioned above, except there is no need for the steam separator because the well only produces steam; therefore the steam is directly used. Most often geothermal plants use water cooling systems and have a capacity factor in the 89%-97% range (Kagel & Garwell, 2005).

With the use of very deep well drilling complication can arise when being applied to a building within an urban area. Teodoriu gives many potential complications from well drilling, which are listed below:

- Risk of explosion
- Risk of pollution of air and potable water
- Noise level and vibrations
- Impact on the landscape
- Conformity with local environmental regulations
- Space taken away from urban development
- Length of time that the rig stays on site
- Footprint of the drilling site

These are problems caused by digging deep wells, which is not always necessary. In the German Parliament geothermal energy was used for heating and cooling the building. What they found sufficient was to dig two wells in which one would be dug shallow, used for cooling the building, while the second was a very deep well which would pertain to heating the parliament (Teodoriu & Falcone, 2008). However, this has not yet been seen as a problem for our project.

Furthermore, there are different types of geothermal systems used for different areas around the world. Most geothermal have a normal drilling depth at 6 kilometers (3.7 miles). When looking at the United States every state has a different temperature at 4 miles into the earth, therefore there has to be different systems corresponding with the different temperatures around the world. A hydrothermal system has two types, vapor-dominated and hot water. In this system, water (usually rain-fall) falls through reservoirs dug deep enough so the water will reach hot rock. Due to the density of the hotter water, it will rise to the top where the system then extracts it out and uses either the steam (vapor-dominated) or the hot water to heat ones home (Green & Nix, 2006, p. 5). The Enhanced Geothermal System (or EGS) is used when reaching 6 kilometers in the ground and the water doesn't reach the hot rocks; therefore the temperature of the water is not hot enough. When using this system, water is forced down to the hot rock and when the hot water rises up injection wells extract the water, just like if it was a natural occurring hydrothermal system (Green & Nix, 2006, p. 7).

Direct use of hot water from a geothermal resource is mostly seen in building heating, crop and lumber drying, ice melting on sidewalks, roads and bridges and also heating districts. This is when a well brings hot water to the surface and a mechanical system takes that water and

passes it onto its intended purpose (Green & Nix, 2006, p. 8). Now, the large resource for heating buildings and hot water are the geothermal heat pumps. These pumps use “conventional vapor compression heat pumps” that extracts the heat from the Earth to use for space heating (Green & Nix, 2006, p. 9). These heat pumps are shown to be four times more efficient than electrical heating (Martin & Maze, 2008). In the summer this process is reverse so your home stays cool. Geothermal has many applications and is an amazing alternative to natural resources. Not only can it produce space and district heating but it can, in some conditions, produce electricity too.

2.5.2 Solar Heating

Solar heating is another renewable resource used for building heating. A Solar heating systems uses the power of the sun to produce energy. The advantages are that solar heating reduces harmful air emissions, protects the environment and reduces utility costs. There are two different types of solar heating; there is active and passive solar heating system. Active solar heating works independently so it is becoming more popular. Active solar heating involves a heat collector, heat storage tank, supplementary heater and controller system (Gao & Li, 2006). Heat is gathered by the collect and then dispersed into the house. If there is extra heat it will be held in the heat storage tank and if there is not enough heat to supply the house then the supplementary heater will start.

Passive solar heating consists of less technological based processes in which one can heat their home. There are three different types of passive heating: Direct gain, indirect gain and isolated gain (Solar Space Heating and Cooling, 2008). Passive heating is more about design, such as large windows facing to the south toward the sunlight, this will capture heat throughout the day and the heat will then move into the remaining rooms of the house. This is a perfect example of isolated gain, heating a specific room so that sequentially the room can bring heat through the rest of the household. An example of direct heat would be installing a specific type of flooring in the house that will absorb heat from the sun and keep warm during the night. Indirect heat is best described as the walls within the home, which heat up due to the sun during the daylight hours and stay warm partly through the night.

2.5.3 Biomass Heating

Biomass is becoming more popular due to the high prices of oil. It is a renewable energy that could possibly replace fossil fuels and can be used for heating, electricity and even vehicle fuel. Also known as “bioenergy”, biomass is a rapidly growing technology in the United States. It is created from plant and wood materials along with animal wastes. This material is put into a furnace and combusted, which will produce either hot water or hot air (Biomass, 2006). The hot air is normally used for space heating, whereas the hot water can be used for domestic hot water system or for central heating. The biomass product can also be used for heat and electricity at the same time, where the biomass is burned to produce heat and electricity. In order for biomass heating to be an option, the building would need an unlimited supply of waste materials therefore not being feasible for our building.

2.6 Electricity Alternatives

Within an urban environment, electricity production exerts a large amount of greenhouse gasses daily. The needs of sustainable building techniques are essential and producing electricity in an environmentally friendly way holds high importance. One of the simplest ways to produce electrical energy for buildings is the use of photovoltaic cells. Furthermore Wind harnessing systems and emphasis on energy efficient appliances are two more ways that buildings can become more efficient energy users.

2.6.1 Photovoltaic Cells

With the buildings in the U.S. using 72% of the produced electricity (US Green Building Council, 2008) and electricity production having one of the largest Greenhouse gas production rates, it is important that all of human kind begin to build with sustainability in mind. Sustainable building techniques aim to reduce the use of natural resources in such a way that the building needs no outside input of non-renewable energy, such as fossil fuels and grid delivered electricity. Production of energy through fossil fuels accounts for 85% of fossil fuel use. (Shannon & Chughtai, 1995) This means that buildings need to integrate environmentally friendly devices to harness renewable energy.

The same solar energy that can be used to heat buildings can also be used to generate electricity using photovoltaic cells. A photovoltaic cell is a very simple device. Discovered by

accident in 1940 by Russel Ohl, the semiconductor solar cell is made up of two slightly different forms of silicon. The two types of silicon used are positively and negatively doped, and hence the names p and n type silicon. When light shines on a wafer of silicon each photon of light imparts its energy on an electron releasing it from its energy level and the p-n junctions direct all of the free electrons in the same direction, thus causing an electrical current to flow. These Wafers of silicon produce less than a volt and are about 125mm wide but less than half a mm thick. So to get more useful current/voltage values larger panels are many up of many cells that are strung together in series and parallel combinations. These larger panels can then put in arrays to produce large amounts of energy in the kW's range. Typical panels today are only 20-30% efficient, however with newly developing technology panels are expected to begin to approach the 93% efficiency determined by thermodynamics (Photovoltaics: Technology Review, 2000)

Photovoltaics are rather expensive to implement because of their high manufacturing cost nevertheless, the upside of solar panels is that the pay-back for most systems is only a few years and once they are paid back they produce energy at no cost, monetary or economical. With the advances in photovoltaics, solar arrays are becoming more efficient and less costly. The two largest buildings that we are dealing with in this renovation project are 5 stories tall and stand facing the south. This means that the roofs are perfect for solar because they have an unobstructed view of the sun at all times during the day.

2.6.2 Wind Energy

Another form of renewable energy is the wind. Wind is a flow of molecules and for those molecules to move they have to have some energy applied to them because matter doesn't just move on its own. Hence there is energy in mechanical it is possible to harvest that mechanical power to convert it into electricity. When the windmill was first conceived hundreds of years ago it was used to turn the wind energy into mechanical energy to grind up wheat to make flour. The windmills of today simply turn the rotational energy of the fan blades into electrical energy.

The wind is a natural and geographically specific source of energy. The coast always has wind because of the sea and land breeze effect and thus it is the best candidate for wind power generation. There are other places however that have wind for similar reasons; Their geographical location constantly creates wind at a certain level. There are maps that show areas that have this wind producing capability. The western part of the United States has strong

constant winds as well as having lots of open space and thus arrays of wind turbines can be put out there to generate electricity.

2.6.3 Energy Use

There are many ways that heat and electricity are generated, but the easiest way to reduce greenhouse emissions from energy production is by reducing the amount of energy that we use which is a much simpler task than we may perceive it to be. Conservation of heat is simply done by making our homes more air tight and insulated better. However there are many things that can be done to reduce the use of electrical energy. Every household has many devices that use power. These devices are not only things like cell phones, computers, televisions and sound systems, but also devices we don't turn off like refrigerators, electric water heaters, dishwashers, and other household devices that are always plugged in. These devices all use power, and those sitting in standby mode account for almost ¼ of domestic energy use. (Sanchez, 1998) . So by using more energy efficient appliances it is possible to reduce the amount of energy use drastically.

With the use of energy becoming more of an issue, the US Government has begun efforts to promote energy efficient devices and homes. There are two major programs that have been started. The first is called Energy Star is a program run by the US Environmental Protection Agency and then US Department of Energy. It is also apparent that the program is working because just last year alone Energy Star helped American consumers save about 16 billion dollars on utility bills and prevent about 27 million cars worth of greenhouse gas emission. (Energy Star, 2008). The second is the Leadership in Energy and Environmental Design (LEED) green building rating system. This rating system was established in 1998 and now provides a set of guidelines for sustainable building.

2.7 Water Alternatives

In the growing world of green technology, water use and conservation is becoming more and more important as the availability of this natural resource is becoming more scarce. Buildings and households are extremely inefficient in their use of water. “Between 1900 and 1995 water use in the world has increased by a factor of six that is more than double the rate of population growth.” (Niemczynowicz, 1999)

The amount of water used daily with old toilets, showers, top-load washing machines and water running into our sinks is taken for granted. In order to conserve water intake the use of water saving utilities including dual-flush toilets, front load washers, and low pressure shower heads stand as simple and cheaper solutions. This water use in our dish washers, sinks, bathtubs, and washing machines make up 50-80% of all the freshwater we use daily. (Niemczynowicz, 1999)

2.7.1 Greywater

One of the new developing green technologies in homes and buildings is called *greywater reuse*. Greywater is the discharged water from our washing machines, bathtubs, showers and sinks. Greywater, however, does not include *wastewater* from kitchen sinks, dishwashers or toilets. (Al-jayyousi, 2003) Since this greywater is not truly wastewater, the purification process is simpler and less expensive, allowing the water to be treated and reused without leaving the building. So far the only safe reuse for greywater is in toilets, outdoor use, groundwater recharge, and landscaping. (Al-jayyousi, 2003) However, in the near future, with further advancements in treatment systems, we will eventually be able to reuse greywater in washing machines, showers, bath tubs, sinks and dish washers. Greywater reuse will still be a valuable tool in limiting water use since toilet flushing is responsible for 30% of all water usage in home, while in office buildings this number increases to 63%.. (CIRIA, 2001)

In order to be reused, greywater must meet current EPA standards for water usage. “GW from recycling systems should fulfill four criteria: hygienic safety, aesthetics, environmental tolerance, and technical and economical feasibility.” (Al-jayyousi, 2003) The main concerns of reusing this water is the amount of coliforms and fecal matter contained in it. Currently, there are two main types of treatment available for greywater reuse. Coarse filtration along with disinfection represents the most common technology used for domestic reuse. “The coarse filter usually comprises a metal strainer. Disinfection is achieved using either chlorine or bromine, dispensed in slow release blocks or by dosing a liquid solution.” (Al-jayyousi, 2003) This type of water filtration and disinfection has been shown to save up to 33% of water usage. (Al-jayyousi, 2003) The other type of water filtration uses a membrane material as a permanent barrier to suspend particles. Coarse filtration would not likely be adequate to provide water for the Crompton Knowles Loom, making the second membrane filtration system a more likely solution. Membrane bioreactors, which combine an activated sludge reactor with a

microfiltration membrane, have also been successfully employed in office block and residential buildings. (Al-jayyousi, 2003)

Another viable option in greywater reuse is a smaller type of system than other centralized filtration systems. This type of system which is often referred to as an AQUUS System relies upon an individual toilet and sink connection. They are much more cost effective and can be used in all types of settings. These greywater reuse systems do not require the large amounts of piping required in typically greywater facilities. They can also be placed in the residential sections rather than office sections, since office buildings do not produce as much greywater as residential spaces do. (Charles and Hudson, 2009)

With the potential for commercial and residential areas at the Crompton Knowles Loom, greywater reuse would help in water conservation, as well as possible water for agriculture and groundwater recharge. Greywater systems will not provide immediate cost benefits due to the expensive filtration system. However with a possible addition of rainwater collection included into the greywater to be filtered and reused, the system could provide substantial amounts of water to be reused. Hopefully with further developments in the areas of greywater reuse, the filters will allow for the water to meet EPA standards and make the water in a building completely self-sustaining.

2.7.2 Wastewater

Wastewater management and recycling is another valuable way for possibly reusing water resources. Wastewater differs from greywater in that it is more contaminated and in turn, more difficult to be treated. This type of water can be reused through two major sources; central wastewater treatment plants and in onsite wastewater treatment facilities. (Junying Chu, 2004) Treated wastewater typically can be reused in the same ways as greywater, with the only real difference being the possible use of greywater as drinking water. This recycled water can be utilized for agricultural irrigation, landscaping, groundwater recharge, industrial use, toilet flushing and possibly cooling for thermal power plants. In residential and commercial areas, wastewater is usually characterized by the water used to flush toilets, along with discharge from dishwashers. With on site wastewater treatment expanding as a new technology, the treatment systems differ in style and results. Membrane processes which flow wastewater through a specially made and sized membrane, trap some of the waste particles from continuing in the flow of the water while also allowing for reuse of auxiliary particles or nutrients left over in the

membrane. (M. Marcucci, 2001) These membranes must be selected based on many factors including pore size, membrane material, and membrane shape. All these factors help determine the quantity and size of materials which is allowed to pass through the membrane. (M. Marcucci, 2001)

This use of membranes in treating wastewater appears to be the most common process. Alternative ways to treat wastewater include microfiltration, ultrafiltration and nanofiltration. These treatments can be used on their own or more effectively in sequence with one another. These three filtration treatments remove substances from the water to different extents, with Nanofiltration separating organic compounds and salts from the water. (M. Marcucci, 2001)

For the Crompton Knowles Loom, wastewater treatment could be implemented into the water system as a way to treat and reuse the water from toilet flushing and dishwashers. These types of water treatment systems can be costly, with the need for operating and management costs to keep the systems operating and providing consistent water quality. (Junying Chu, 2004) The outcome in overall water quality and the possible use to serve as water for toilets as well as irrigation for exterior landscaping and the rooftop garden, make the implementation of such a water system technically feasible. The ideal gain of the system will be an overall reduction in the freshwater intake from outside sources, as well as the wastewater discharge, possibly cutting both quantities in half. (M. Marcucci, 2001)

2.7.3 Storm water

One of the longtime concerns of those associated with green technology is managing storm water and its runoff. “When it rains storm water runoff that isn’t properly managed can flow over impervious surfaces picking up pollutants along the way and washing them into rivers and streams. Storm water runoff can also cause flooding and erosion, destroy habitat and contribute to combined sewer overflows.” (Hauth, 2008) Common storm water management plans that could apply to the Crompton Knowles Loom Manufacturing Building include infiltration basins, permeable pavement and storm water management ponds.

Infiltration basins are low points or small ditches towards which water is designed to flow. These ditches allow the water to penetrate the ground through the upper soil surface. These basins would stop the water from running over off the paved areas and into surrounding water ways or other habitats surrounding the building or immediate area. This would ultimately

limit pollution of ecosystems caused from the pesticides, fertilizers and treatments that have been spread on roadways and other surfaces in the area, which is the main concern of storm water runoff. (Debo & Reese, 2002)

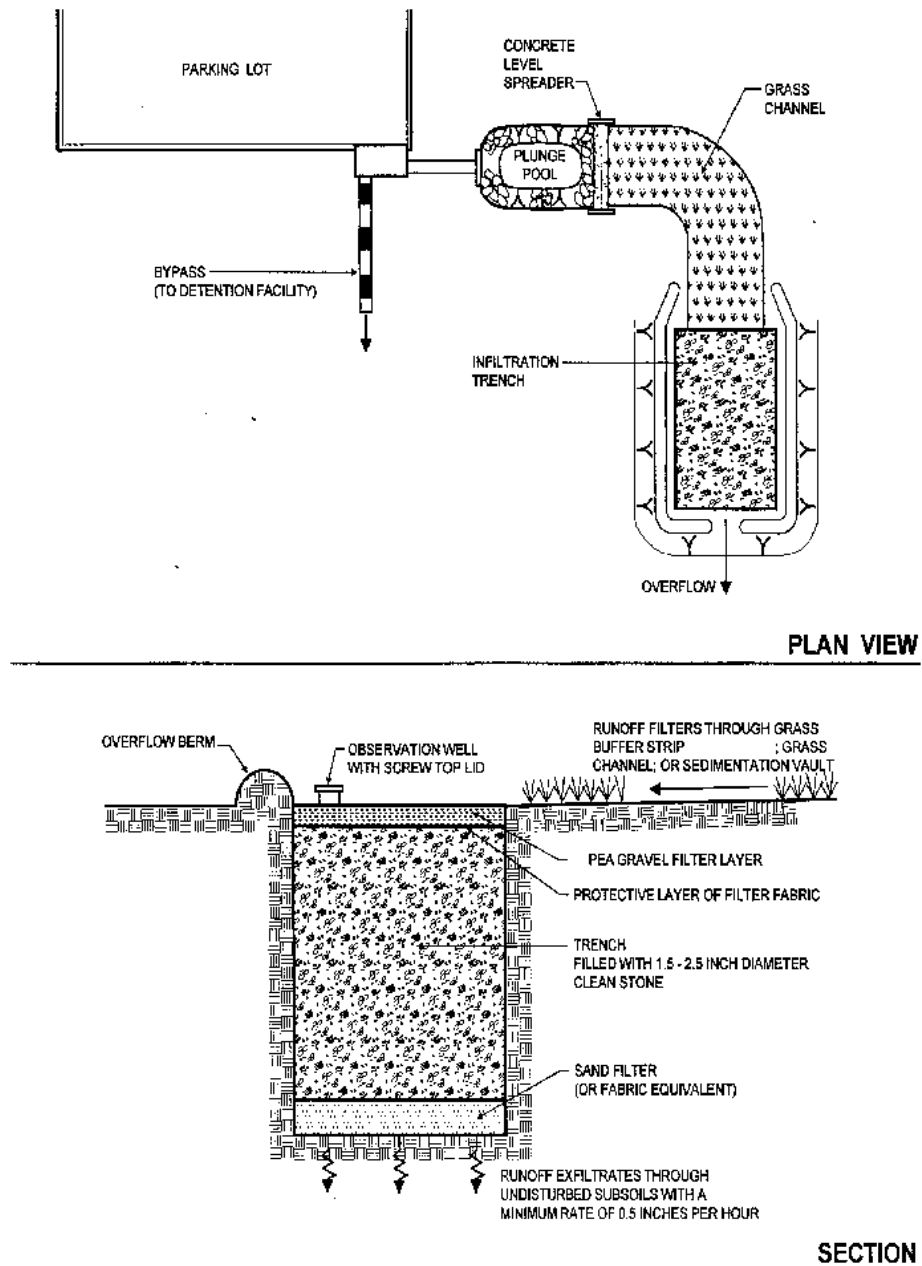


Figure 1. Infiltration Trench

Figure 4: Infiltration Trench (Stormwater Center, 2009)

Another possible solution is the application of permeable pavement to the area surrounding the building and its parking lot, which is a more recently developed technology. It acts much in the same way as an infiltration basin, by allowing water to enter back into the soil, rather than running over the surface into surrounding ecosystems. However, instead of having actual basins, the pavement allows water to actually pass through it, into the ground. (France, 2002)

Storm water management ponds are another very common way to prevent storm water runoff. They can often be seen outside of large parking lots that have forests or waterways nearby. They are used to hold large amounts of water after rain or storms, and prevent the water from running into the area's ecosystems. They are large, however if well kept can be seen as attractive areas capable of providing for nature if properly cared for and tended to. (France, 2002)

Storm water management is an aspect of green technology that is not directly pertinent to the Crompton Knowles Loom itself. Currently storm water management is being looked at more in terms of the environment and ecosystems surrounding buildings rather than buildings themselves. We still can incorporate many products in our building that are ecologically friendly and will not harm the environment by adding pollutants into the runoff from the building. The possible addition of a rooftop garden will also assist in controlling runoff and storm water problems that the building may cause due to water running excessively through downspouts and off of the building. "Storm water may in the future constitute an important resource possible to re-use separately or together with "greywater" for toilet flushing, irrigation in urban small-scale urban agriculture or even for production of drinking water."

2.7.4 Rainwater Reuse

One aspect in storm water management that could be applied to Crompton Knowles Loom is rainwater reuse. The ideal system would treat both the greywater and rainwater, yet since rainfall is unpredictable, and rainwater is more easily treatable, two different treatment systems may be the best option. Rainwater filtration usually can simply use a filter and a chemical or UV treatment/disinfection process. Rainwater systems typically need less maintenance and are cheaper to operate than greywater systems. (CIRIA, 2001)

Like any water collection system, there are questions as to the regulatory use of water collected from rainwater systems. It is thought to be a cleaner source of water than treated greywater and wastewater, however this would have to be regulated by the EPA. Due to this fact, rainwater has been reused in the same ways as greywater and wastewater, being for agriculture, toilets and occasionally dishwashers. The water is typically received through “collection, assured by the surface of the building on which the rainwater flows and falls down,” and “conveyance, toward the cistern through gutters, drainpipes, manholes and sewers.” (de Gouvello, Derrien, & Khouil, 2005) A common problem with rainwater reuse is that the roofing materials pollutes the rain upon hitting the roof. One can conclude from this is that by utilizing materials that will not release pollutants into the rainwater on the roof, the water can be reused with much less treatment. Treatment of the rainwater is typically broken into three parts, “weeding out at the head of drain pipes, water treatment upstream, and filtration downstream to the storage cistern.” (de Gouvello, Derrien, & Khouil, 2005) Storage systems would have to have a tank, along with meters to manage the level as well as overflow valves to keep the tank from overflowing. There would also have to be a pressurized pumping system to allow the water to be transported around the building.

In order to recycle the most water possible in attempt to create a building with a self-sustaining water system, greywater reuse, wastewater treatment, and rainwater collection all provide viable options for collecting, treating, and reusing water in one form or another. Since technology has not advanced to the point where water can be internally treated and made drinkable, the Crompton Knowles Loom, as of right now, will not be completely self-sustaining. However with as much as 80% of all water use coming from utilities such as sinks, toilets and washing machines, being able to reuse this water would save substantial amounts of water, and, eventually money. A building the size of the Crompton Knowles Loom would inevitably go through large amounts of water, both inside, and out, and being able to reuse water for toilet flushing, exterior agriculture, and the rooftop garden would be economically feasible.

2.8 Structural Alternatives: Rooftop Gardens

One of the most popular green technologies that has been applied to buildings is the addition of rooftop gardens. Rooftop gardens are not the usual garden people think of today. It is a certain type of plant placed in soil for technical uses, with aesthetics being an afterthought.

Rooftop gardens will provide a better overall environment, while helping to control storm water runoff and providing better insulation for the building itself. Rooftop gardens are said to provide advantages as an amenity, ecological benefits, technical benefits and eventual cost benefits. The basic ecological and technical benefits they provide include better air quality, insulation, storm water runoff management, and a lower microclimate temperature. (NH Wong, 2003)

The major problems associated with a green rooftop would be the high initial costs associated with such a project. A rooftop garden may cost three to six times as much as normal roofing would; however over time a rooftop garden has been shown to outperform a conventional roof. A more vital drawback to a possible rooftop garden, especially regarding the Crompton Knowles Loom manufacturing building is the ability of the structure to adequately withstand the added weight of the garden. (NH Wong, 2003) Studies performed on a five story building with a newly installed rooftop garden showed rather large positive effects on the interior of a building. The insulating effect of the garden showed to save up to 15% on the buildings energy usage. Also, with the roofs ability to absorb the sunlight and limit the thermal effects of the sunlight on the building, the cooling expenses of the building were reduced by 79%. (NH Wong, 2003) The results of this study, when adapted to a three story building, would have an even greater positive effect on the energy and air conditioning savings.

The Crompton Knowles Loom manufacturing building has a large flat roof which could easily be covered with a rooftop garden. This would provide great insulation for the building itself while helping the overall environment. It would save energy inside of the building since it would cut the cooling costs in the summer by ending thermal radiation, as well as cutting the heating costs of the winter by providing better insulation. Ideally, the rooftop garden would be fed by treated wastewater, rainwater and greywater from the Crompton Knowles Loom. (Wong)

One rooftop garden will not solve the problems of global warming all by itself, because the effects it will have on the overall atmosphere and ecosystem will be too small to notice. However, hopefully this rooftop garden can stand as a symbol and a starting point from which other companies and contractors can follow. As green rooftops proliferate, we will start to see a positive effect against the cause of global warming.

2.9 LEED Certification

The United States Green Building Council created a rating system known as LEED (Leadership in Energy and Environmental Design) to attempt to accelerate the adoption of green building practices. LEED had been originally designed as a rating system for new commercial buildings but has become a model for other building sectors and regulatory programs. The United States LEED system is very similar to BREEAM which is the United Kingdoms equivalent. The Green building rating systems generally focus on five categories of building design and life cycle performance; site, water, energy, materials, and indoor environment. (Krishnan, 2004)

<i>Category</i>	<i>Points</i>
Sustainable Sites	14
Water Efficiency	5
Energy & Atmosphere	17
Materials & Resources	13
Indoor Environmental Quality	15
Innovation & Design process	14
Total	69

Figure 5. LEED Point System

<i>Level</i>	<i>Points</i>
Platinum	52-69
Gold	39-51
Silver	33-38
Certified	26-32

Figure 6. Points required for LEED Ratings

(Macaluso)

The LEED Certification works on a system of credits. Each credit represents a green technology utilized in or around the building. Some of the technologies are required in order to earn a LEED certification rating, while others are options of technologies that can be placed in a

building. All these technologies or credits installed into a building can be added up, and based on this number a building can earn a LEED Rating. These ratings range from Certified, which is the lowest, onto Gold, Silver and finally Platinum, which is the highest. (LEED Rating System, 2008)

The following is a sample of some of the required technologies and some of the possible credit technologies that can be installed in a green building based on the LEED Certified ratings.

- Sustainable Site Requirements include; an erosion and sedimentation control plan, temporary and permanent seeding, mulching, Earth dikes, silt fencing, and sediment traps and basins.
- Possibilities for Sustainable Site Credits include; a transportation survey, bicycle storage and changing facilities, carpool management services, pervious and open-grid pavement, storm water detention products, green roofs, storm water management systems, onsite infiltration products, and lighting design modeling.
- Possibilities for Water Efficiency Credits include; high efficiency irrigation systems, greywater management systems, cisterns, rainwater storage tanks, waterless urinals, low and dual flush toilets, and constructed wetlands.
- Possibilities for Energy and Atmosphere Credits include; energy efficient water heaters, lighting, windows, and appliances, as well as, onsite renewable energy production, fire suppression systems and energy usage metering equipment and controls.
- Possibilities for Material and Resource Credits include; construction and demolition waste management, salvaging, refurbishing or reusing materials, locally manufactured products, the use of recycled materials, the use of rapidly renewable, and the use of certified woods.
- Possibilities for Indoor Environmental Quality Credits include; CO₂ and airflow measurement equipment, building automation systems, raised floor systems, indoor air quality management plans, low emitting materials, entryway systems, air filtration systems, lighting controls, thermal comfort controls, and delighting computer simulations. (Development, 2007)

2.10 Sustainable Communities

An important aspect of our project will be instilling a sense of a sustainable community within the mix use building that will be eventually produced by the Main South CDC. A sustainable community is a centralized population that undertakes environmentally friendly practices in order to reduce energy use, pollution and other harmful practices. (About Sustainable Communities, 2002) The most important aspect from a planning perspective is to lead the people within the community towards sustainable practices, or a “sustainable lifestyle.” In order to do this, buildings must be fitted with sustainable lifestyles in mind, making space for biking, carpool parking, using sustainable products, using rapid renewable, composting waste, and recycling products. (Diversity, 2008)

One of the best sources for creating a sustainable community that practices sustainable living is to educate the inhabitants of the community itself. Ideally people will be attracted to the establishment due to its identity as a “green building,” however once people become tenants, outside of simply providing people with sustainable lifestyle practices, it is important to also educate them about the benefits. It is believed that unless given significant reason to, as an example, recycle a bottle rather than throw it away, people are more likely to recycle. So this education and creating an awareness within the establishment will also be extremely important to the building and the “sustainable community” itself. People must understand that living in a green building does not make them sustainable people, practicing a sustainable lifestyle makes someone sustainable. (Girardet, 1996)

Chapter 3: Methodology

The Crompton and Knowles Loom Manufacturing Corporation use to be at the center of our community and since this large complex has now gone abandoned the community has changed dramatically. This project will give out sponsor a starting point for the renovation project at 93 Grand such that the building will be a benefit to the community. To accomplish the goals for this project we will focus on three main areas. The first area of focus is the Community. This area is important to study because for a large building such as ours the building must fit the needs of the community. We will be able to present, through our research, what makes up our community. The second area of focus for our project is the Building itself. We will gather as much information about the building as we can so that our sponsor can have a centralized source of information on the building. The information that we gather about the building will be mostly items that already exist such as blueprints and surrounding ground data maps. The Third area of focus in this project is the feasibility studies of several key green technologies. These studies will give our sponsor a better idea of which technologies to incorporate into the renovation of our building and will give a solid platform for which designers can spring from.

3.1 Community

The community of Worcester, and more importantly, the Main South district will be extremely important in the development of our project and report. In order to provide the best possible product for our sponsor, The Main South Community Development Corporation, we must investigate the wants and needs of the Main South area. The people of Worcester are going to make up the residents, shoppers, developers, and employees of this development, so it is crucial to incorporate their opinions and ideas into our overall plan of action.

The Main South CDC held Design Charrettes on December 10th and 11th to gain a better understanding of the possibilities of green technologies and the priorities of the community in the development of the Crompton Knowles Loom Manufacturing Building on 93 Grand Street. The Charrette of the 10th hosted a series of experts in the areas of green technology, while on the 11th the Charrette hosted members of the community to voice their opinions for the project. A consensus from the Charrette was that the project should take on a strong outward posture towards the community. By an outward posture, everyone felt that the final product should be a

sustainable building that incorporates the community by possibly providing attractions, recreation, housing, business and shopping opportunities.

After receiving the final report of the Design Charrette, Ms. Middaugh gave us specific requests that would be most useful to the Main South CDC while in the beginning steps of the project. While not knowing what is to become of this building, getting to know what is around the building would be the best place to start. To provide incentives for future residence, knowing the surrounding businesses and places of interest will be very important. Furthermore, if the Main South team decides to home businesses in this building, knowing businesses in the community will give them an idea of what the community needs. Moreover, we will provide the demographics of the area so our sponsor can make appropriate decisions that will unite this building with the community.

3.1.1 Community Mapping

Our main objective in the community section of our project was to create an in-depth map of the community area surrounding the 93 Grand Street building. We were given a set of boundaries from our sponsor to use for the “community”. With these boundaries in mind we walked the streets of the community taking note of what businesses were in the community and where they were located. From that information we then made a map that shows where in the community each business. Not only is each business on the map but each business is also color coded according to its type.

3.1.2 Green Child Care Case Studies

One of the requests we received from our sponsor was to look into the feasibility of a possible Green Child Care Center. We were very pleased to find that there are in fact many green and eco-healthy green child care centers around the country. A green child care center is one that is environmentally friendly. They take measures to ensure that the environment provides the best in health for children, offer locally-grown or organic food, and celebrate multiculturalism. Also children are taught to respect the earth and its precious resources.

The Oregon Environmental Council (OEC) provides an Eco-Healthy Child Care Checklist which has 25 environmental-health criteria for daycare centers. Of those 25 criteria, daycare centers must meet at least 20 of 25 items. 2 of the 25 items are mandatory: The use of

nontoxic techniques to control pests and no smoking anywhere on the premises or in sight of children (Eco-Healthy Child Care Checklist, 2007-2008). This checklist acts as the guidelines for most of the green child care centers we have researched. So far this program that was created by the Oregon Environmental Council is endorsed by more than 230 daycare centers in the United States. The OEC's program acts as the basis for the current movement of daycare centers from conventional, to a more environmentally friendly basis. These daycare centers traditionally do cost more than typically daycare center due to the added cost of sustainable construction and building materials. However, as sustainable building becomes more common, the cost of such buildings is greatly decreasing which will also bring down the added cost of green daycare centers.

We have been able to identify local green child care centers which have been included in the binder. From these you may be able to visit each center and try to use them as a basis for a possible green child care center at 93 Grand Street. We were also encouraged when we found that the report we received from Lamourex, Pagano Associates proposed making building 35 into a child care center.

3.1.3 Demographic Data Collection

In order for the Main South CDC to know what would best suit this building, they will need to know the demographics of their community. Presenting our sponsor with general, social, economic and housing characteristics, will provide them with the information they need to make appropriate decisions about the building. After contacting Laurie Ross from Clark University, we were able to find all of the demographic information on U.S. Census Bureau website.

In addition to the demographics of the Main South community, we have also supplied the demographics for the 01610 zip code region, along with the demographics of the United States. With this information our sponsor will be able to compare their community to the surrounding communities within their same zip code and also a look at how each compares to the entire United States. The general characteristics will give information about race, the average household and family size, and the owner vs. renter occupied housing units. The social characteristics will entail the education levels and the language spoken in the home. The economic characteristics provide the average household, family and individual income levels, along with the poverty levels. Lastly, the housing characteristics will give our sponsor the

median value of a single-family owner-occupied house and what the average mortgage is for those families.

3.2 Building Information

A critical aspect of our project as we moved forward in our research was to collect all the possible information about the 93 Grand Street building we could locate. By gathering all of these documents and other information regarding the building we would be able to compile it all in one central spot to be easily accessed. With these documents and other information we found that we could provide our sponsor or an interviewee with all the necessary information for them to make an educated assessment of our building without needing to visit the site. The building information aspect of our project was an information and documentation gathering process, however the results of this will be extremely helpful as Main South continues their work in the 93 Grand Street project.

3.2.1 Ground and Building Plans

Gathering the ground and floor plans was one of our first tasks we undertook in our project. We felt that these documents would not only assist our group in our investigation, but also assist our sponsor in their future work on the project.

We started by visiting the Worcester Public Library to view their public records. We were only able to find very old documents showing the area soil types. Our next step was to visit Worcester City Hall to view their public records. There we were informed that they did not have the information we were seeking and that we should contact the Worcester Department of Public Works. Upon contacting the Worcester DPW we received several maps depicting the sewage systems surrounding the 93 Grand Street building.

In order to find documentation on the building itself we started by asking our sponsor for any possible blueprints and land use maps that they had. They provided us with multiple maps of the building and the surrounding area. We were able to find other materials later in our project after visiting Michael Pagano at Lamourex, Pagano Associates. He provided us with a previously conducted report that included many land use and building maps that completed our search for building plans. After gathering all our documentation, we organized it into a binder to make access to the information easier for both us and our sponsor.

3.2.2 Researching Green Suppliers

A critical aspect of sustainable building is using local green suppliers. A core belief of green building is to support local suppliers who offer green building materials. Construction on the 93 Grand Street project is not going to begin for a couple of years, however we felt that it would assist the Main South Community Development Corporation if we provided them with a list of local green suppliers they could contact for building materials. We researched through listing and local catalogues for local supply companies who offered the green materials used in today's sustainable construction.

Upon indentifying many local suppliers from green building guides and other lists, we researched each individual company to ensure that they did indeed carry green building materials that Main South could use in its construction project. After ensuring the reliability of these suppliers, we created a list including all contact information of each supplier. We also created a map showing where each supplier is in relation to the Main South community.

3.2.3 Price Point build-Outs

Another idea proposed by our sponsor was to create a series of apartment build-outs using a price point system. We created a conventional apartment using conventional building materials, and determined the price of this type of apartment. From here we created three increasing levels of green apartments defined as +1, +2, +3 and possibly +4. As the level gets higher, the apartment will have more green materials than the previous apartment build out. Our first step in accomplishing this task was to research the materials that would make up a conventional type apartment including the price per square foot. Our next step was to research all the viable green building materials that could be found in a modern green apartment. Major factors in identifying these materials was, to the best of our ability, ensure that they could be purchased locally and were grown locally.

Once we had identified green building materials, we started to classify them by categories. We broke all the materials into flooring, cabinetry, countertops, bathroom walls, and toilets. We also agreed that all green apartment build outs would include green paints, stains, shower heads, sinks, and compact fluorescent light bulbs. After identifying each category, we separated all materials in each category by price, with the cheapest material going to the +1 and +2 price point build outs, and the most expensive going to the +3 or +4 build outs.

3.3 Green Technology

The primary focus of this project is on the technologies that will be implemented on the building. Focus groups with experts and professionals will hold extreme importance in the procedure of finding what technologies are feasible for the Crompton Knowles building. Furthermore, follow-up interviews with some experts in specific fields will give us a better understanding of what technologies are or are not applicable to the building, including why this is true. After having a good understanding of what specific technologies are the most feasible, we will provide our recommendations for what technologies are best for the Crompton Knowles Building.

3.3.1 Focus Groups

The Crompton Knowles building is located in downtown Worcester where the community will be most affected by the changes made to this building. To ensure that the renovations reach their highest potential, the input of the community and experts hold extreme importance. In order to fulfill these requirements the Main South CDC organized two Design Charrettes, held on December 10th and December 11th. Professional opinions and suggestions were discussed during the first meeting and the community's opinions were taken into consideration in the latter meeting. In this section we will be discussing the happenings of the design charrette held on December 10th for the experts and professionals.

The meetings which took place at the Main South CDC building lasted about two hours. There were a total of 30 experts involved who were either from Worcester or they had worked with the CDC prior to this project. Those who attended were skilled in many areas from solar, geothermal, rooftop gardens and energy efficiency experts, to architects and construction managers. The experts in solar design who attended the charrette were Matt Root from the Conservation Services Group and Matt Arnar from Solar Flair. There were three professionals from the Center for Hope in Southbridge, Cindy Howard, Jim Howard and Roger Poirer who were experts in the field of geothermal systems. Thaddeus Szkoda was also a geothermal expert who attended. Lynn Denninger from Cannon Design and Jack Moran from Cutler Associates were there as green roof experts. Alberto Cardenas also appeared at the charrette, who is an architect from Domenech Hicks and has been working with the Main South team prior to this project. Steve Teasdale and Brian McGrail, the project managers, also attended the charrette.

Upon first arrival at the meeting on December 10th, the professionals were presented with pictures and ideas about the building. Our research team greeted each person and while they conversed amongst themselves about the proposed “green” technologies, we observed their discussions and took notes on the ideas that were exchanged. The group then had an opportunity to hear presentations about the site. Professor Robert Krueger gave a presentation on what could be done to the building and why the Main South CDC was taking on this project. Colm Cryan, gave a presentation about the sustainable development which is underway in Ireland. After these presentations the experts were broken into four groups (decided by the coordinator Peggy Middaugh). Each group was given index cards and was able to look around at various photos of the Crompton Knowles building and site for about 20 minutes. While looking at the pictures, the professionals wrote suggestions and/or comments on the index cards, which included what they thought about the building, what could be done to the building and what they would like to be done to the building.

After they were finished with their comments, they proceeded to their group location where they discussed their various ideas together. Each member from our IQP team was assigned to separate group where we would suggest specific technologies that we had researched and then listen to the professional opinions. Each group was told that they were to come up with a list of ideas and present them in front of the entire group at the end. The facilitator for each group was brought up to the front of the room where they presented the group ideas and the audience was able to make comments. A wide variety of ideas were brought up, including opinions on why some technologies wouldn't work and how some may be more costly than others. Some of the technologies that were discussed in each group included:

- Geothermal heating
- Photovoltaic cells
- Green rooftops (or white)
- Water efficiently, grey water and stormwater
- Solar Hot Water

While this format allowed for a much broader discussion many of the experts agreed to set up interviews with our group so we can have a more detailed discussion about the technology of

their expertise. This also encouraged participation by showing how important the suggestions were and how the Main South CDC would like to encourage expert involvement in the project. This Design Charrette also provided us with a strong lead into our project with very dependable information, and many expert acquaintances which we could contact later for more extensive consultation. After the design charrette, we received a report and summary about the charrettes from our sponsor. At the end of this meeting, the professionals had extracted out some of the more viable technologies for our sponsor, which then gave us a more focused project to work with.

3.3.2 Interviews

In January, we arranged interviews with many of the individuals who attended the Professional Design Charrette. Ms. Middaugh provided us with a list of professionals that attended the meeting accompanied by their final report and summary of the charrette. The interviews with the experts around the state gave us much more detailed information on specific technologies, such as geothermal, solar, rooftop gardens and water efficiency. We found a professional in each of these fields to discuss the feasibility of each technology. After trying to set up interviews with several individuals, we found that a phone interview would be more convenient for the professionals. Furthermore, supplying them with an overview of our project prior to the interview would make our interviews more successful. Since the project center didn't supply a conference phone, we had to use our personal phones to contact the experts. In order to ensure accurate results, one team member would be the speaker and the other two team members would be the note takers. Following the interview, the note takers would compare notes to make sure the information recorded was precise. We found this method to be best for our group and for the interviewees.

To find out the feasibility of a geothermal system being installed we conducted a phone interview with Martin Orio from Water Energy Distributor, Inc. For information of solar energy we had phone interviews with several professionals. The first person we contacted was Bruce Gallagher from Solar Design Associates. After receiving basic information from him we then contacted Matt Arnar from Solar Flair. We also had a phone interview with Matt Root from Conservation Services Group who directed us to Peter Hudde who gave us more information about photovoltaic systems and possible issues with the installation. We also held a phone

interview with Jared Markham from Weston Solutions for information regarding the potential of a green roof. All of the professional contact information can be found in Appendix F.

3.4 The Binder

The main objective of this project is to provide our sponsor with a well detailed and organized conclusion. Our report will assist them in the decision making process of what implementations should be made on the Crompton Knowles building. While sending this electronically will be helpful, creating a binder containing all the data we have collected will provide them with an easier way to access the information. Throughout the term we have collected data on the building itself, held interviews, researched green materials and local suppliers, along with obtaining all the demographic information for the neighborhood. All of this information will be provided to our sponsor in a well organized binder.

The binder will also hold all the documents we have obtained that are not included in the report. Such documents would be sewer system maps and pictures of the building that are not necessary to put directly into our report but can be used as visual aids to those who continue this project in the future. Furthermore, this will be a place where our sponsor can put all of the information they collect hereafter, so they can maintain a well organized and convenient binder to find all of the information about the Crompton Knowles building.

Chapter 4: Results

This chapter of the report will provide the results we have found after completing our methodology section. We will present our findings for each section and discuss its significance. We have found and presented all of the community and building information, along with the results from interviews we held while researching each technology. This section will follow the format of previous sections, starting with the community aspect followed by the building information, technology section and ending with a discussion about what is contained in the binder.

4.1 Community

Information about the community will be needed to assess the upcoming development of the building. A community map will help our sponsor and the future residents in the building. The green child care center is a possible business that our sponsor may introduce into the Crompton Knowles building; therefore research about this will be valuable to our sponsor. Demographic data will give our sponsor an idea of the kind of culture that is dominant in our community, and will also show a comparison between our community, the zip code zone of 01610 and also the United States. Lastly, the real estate research will give our sponsor a sense of how much apartments in the area are renting and selling for, so they can approximate their budget accordingly.

4.1.1 Community Mapping

We feel this map will be an important step in involving the 93 Grand Street building into the surrounding community. Residents of the building will be able to use the map in identifying possible places to shop, eat and find local businesses. This will promote the residents to give their business to the local community and economy, rather than shopping elsewhere. This map could also possibly be used to assist in identifying what types of businesses 93 Grand Street could possibly house. By determining what type of businesses are present in the community, and what type of business is not present in the area, and would likely succeed at 93 Grand. The community map is located in Appendix A.

4.1.2 Green Child Care

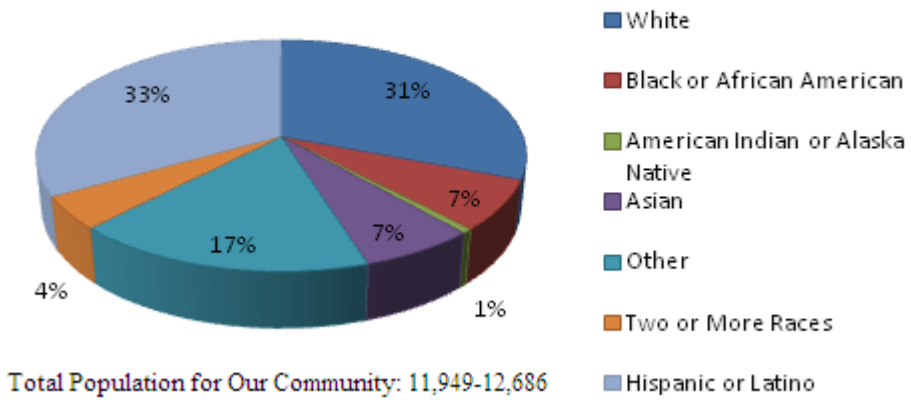
As a result of our study of green child care centers throughout the country we were very pleased to find that there is currently a movement towards green child care centers. This green child care movement was initiated by the Oregon Environmental Council which has proposed a set of guidelines termed the Eco-Healthy Child Care Checklist, which can be viewed at <http://www.oeconline.org/resources/publications/kitsandtipsarchive/2007EHCCChecklist>. We have found that most child care centers that have decided to go green have looked to the Oregon Environmental Council for guidance.

In order to provide Main South with current Green Child Care Centers that could be visited or be viewed as possible examples, we provided a list of current green child care centers in the Worcester area that can be viewed in Appendix G, as well as in the binder. We have also found through community mapping and our research into the current community that there is indeed a need for a potential child care center in the Main South Community as it stands today.

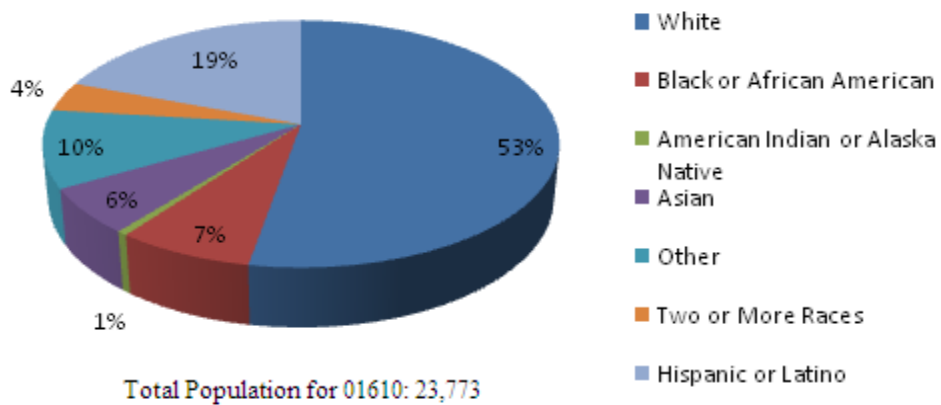
4.1.3 Demographic Data

Presenting the demographic data to our sponsors will give them an idea of the kind of environment the building will need to adapt to. After talking with Laurie Ross from Clark University, we were able to find all of the demographic data on the U.S. Census Bureau. In our data collection we included information on our Community, Worcester 01610 and for the United States. Knowing this information will help in comparing our community to others near us and also to the entire United States. Reviewing the information, we have found that the race percentages in our community are considerably different than the percentages of Worcester 01610 and the United States. This is an important aspect because it will define the dominant culture in our community.

Our Community: Distribution of Race



Worcester 10610: Distribution of Race



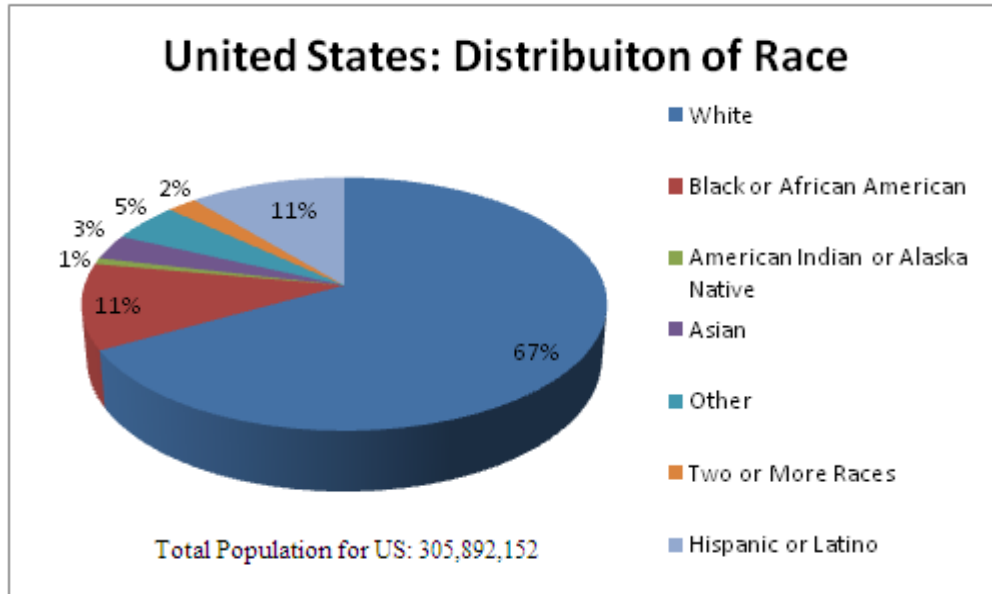


Figure 7. Distribution of Race: Community, 01610, U.S. (U.S. Census Bureau, 1999)

As the graphs show above, the Hispanic or Latino race has the largest distribution in our community at 33%, very different from the 19% in 01610 and the 11% in the United States. This will have to be taken into consideration when adapting the 93 Grand building to the community.

The level of income within the community is another very important element when looking to install housing and businesses into the building for the community. In order to provide the community with housing that is appropriate for their current status, income and poverty levels need to be taken into consideration. The graphs below express the difference in income levels between the three areas of interest, along with individuals and families below poverty level.

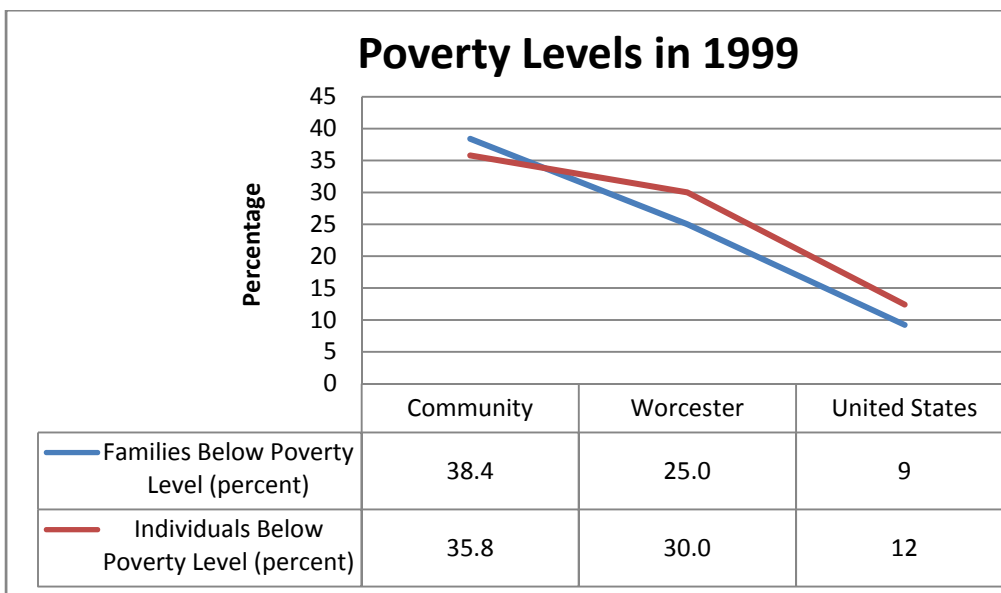
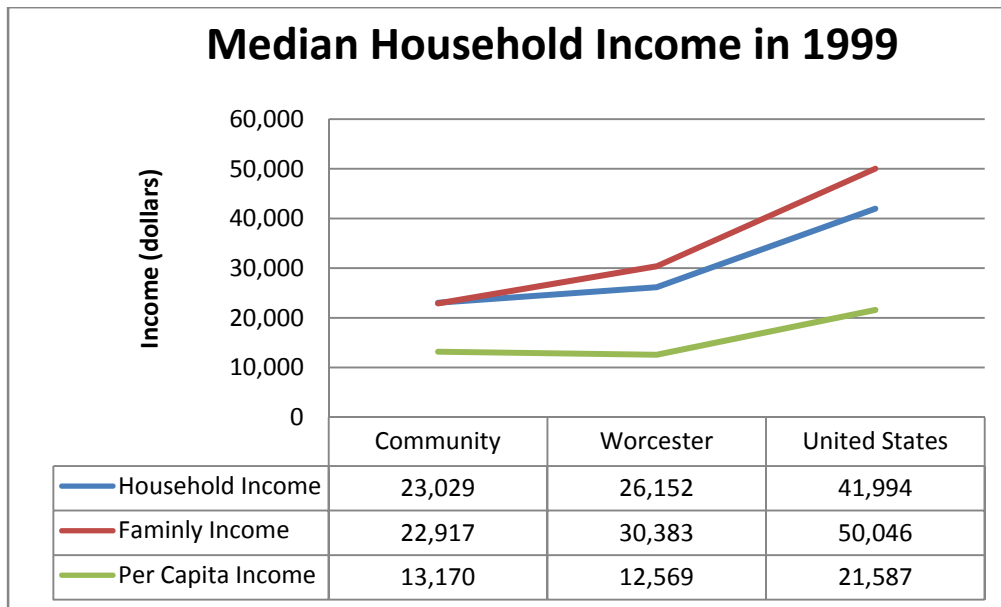


Figure 8: Income and Poverty Levels (U.S. Census Bureau, 1999)

The poverty level in our community as of 1999 is around 38%, which is very high compared to 9% for the United States. Furthermore, the income for a family in our community is around 23,000, which needs to be taken into consideration when determining the rent or selling prices for the apartments they plan to offer. With this information our sponsor could also make other inferences. Since the Main South CDC takes a big interest in the community, they could also look at these levels and try to find ways to improve them. In this community, for the population 25 years or older, the percent of high school graduates or higher is only 50.5-56%, compared to

the United States that is at 80%. Using this information, they could plan to house a business that will improve education levels in the area.

While renovating the building by installing apartment, they will also need to know what kind of housing is needed in the area. For our community the average household size is 2.71-2.84 persons and the average family size is 3.59-3.62 persons. These numbers are consistent with those outside our community and the United States. This demonstrates that apartments should be able to house families of these sizes. Likewise, our sponsor will need to be familiar with how the housing units in the area are occupied. The total household units in our community are between 1,272 and 1,380. Taking into consideration that the average family size is between 3.59 and 3.62, then we know that with these statistics there are only between 4,566.48-4,995.6 individuals being housed in our community, about 40%.. Lastly, our sponsor will need to know if they should rent or sell their apartments. Figure 8 shows the percent of owner and renter occupied housing units in our community, along with vacant homes.

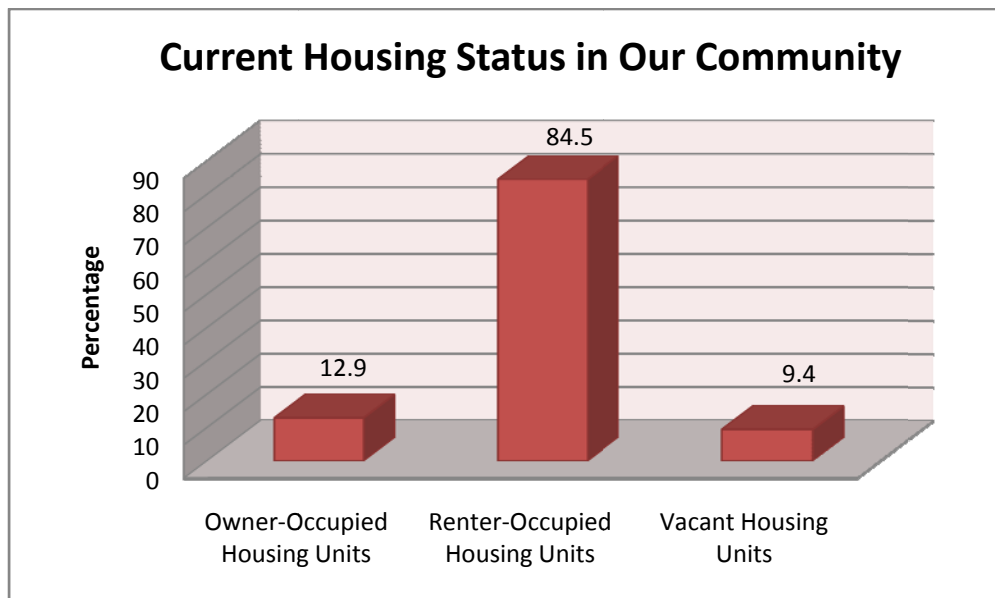


Figure 9: Current Housing Status in Our Community (U.S. Census Bureau, 1999)

For more demographic information please refer to Appendix B.

4.1.4 Real Estate Research

By researching the current real estate market in the Main South community and interviewing William T Lee, we have found that there is a definite need for housing in both Main

South and the City of Worcester all together. The current housing need is far from being met, and a low income housing development would be an appropriate solution to the current problem. There is also research that shows that this type of green low income housing project performed by a non-profit organization is a proven option if federal funding is provided for the installation of green technologies. (Case Studies, 2003) (Caron, 2000)

4.2 Building Information

The building information is necessary for professionals to assess the feasibility of the technologies we have researched. All of the building information was collected for our sponsor and included in the binder we will provide them. The majority of the ground and building plans were easily collected from town officials and the project manager. In order for our community to follow a sustainable design plan, we provided our sponsor with a list of local suppliers so they can give business to local suppliers. The price point build-outs were developed to show the different levels of green technology that can be implemented into each apartment.

4.2.1 Ground and Building Plans

With the help of the Worcester Public Library, Department of Public Works, and our sponsor we were able to locate and centralize all of the plans we received. These plans included several sets of blueprints, land use maps, sewer maps and soil maps. All of these will be accessible to our sponsor if they need any information regarding the soil, sewer or existing building itself when dealing with the future construction project. After locating the plans we were able to centralize them in one common area for easier access and use by our sponsor in their future working on the 93 Grand Project.

4.2.2 Researching Green Suppliers

As a result of researching green suppliers we have been able to identify local green material suppliers in Massachusetts and others in New Hampshire and Connecticut. We have included a short review of each supplier along with their contact information, which can be viewed in Appendix C. We have ensured they provide the materials we have included in our price point build-outs. Using Google Maps we have also provided a map of their location in comparison to Worcester.

4.2.3 Price Point Build-Outs

By looking into the possibility of creating price point build-outs of potential green apartments we were able to identify many modern green building materials that we placed into different categories. We were able to provide the average price per square foot for products in the areas of flooring, cabinetry, countertops, bathroom walls, and toilet types. We also produced +1, +2, and +3 build outs by separating the products in each category with the least expensive being placed in the +1 and the most expensive being placed in the +3 build out. For more information please refer to Appendix D.

4.3 Technology

The main focus of our project is to research green technologies and conduct interviews with professionals to ultimately make recommendations for our sponsor. In this section, we will report what the professionals suggested to do during the interviews, and what we found while researching each technology. Each technology will be examined with the pros and cons of the system, while taking into consideration what experts said about the system and our building.

4.3.1 Stormwater

While conducting research and interviews on the topic of stormwater management we have identified many different types of storm water management. However, it is important to include that the best source of storm water management for our proposed project would be the installation of a rooftop garden. Yet, if a rooftop garden is no longer a viable option following a structural review of 93 Grand's roof, Main South could install several types of storm water management solutions. We have identified three main possibilities for storm water management besides the installation of a rooftop garden. These three potential solutions are infiltration trenches, storm water landscaping including proper plants, and finally the option of permeable pavement. Other stormwater management avenues such as biofiltration swales and detention ponds are not reasonable options due to the size of each and the restricted space we will be working with.

4.3.2 Greywater

In our study we have found different types of greywater treatment systems that could potentially be placed in a building similar to ours. Most systems were very large and costly however simpler systems involving individual sinks and toilet connections. One of the leading

producers of this type of product is the AQUUS Gray Water System. This type of simple system, with a more manageable price seems to be a potential option for our project.

4.3.3 Photovoltaic

Transforming sunlight into electricity is a rather simple idea and does not require exceptionally complex systems to do. From our research we found a number of solar companies that all use the same type of products showing us that the world of commercial and residential Photovoltaics is a pretty level playing field. After speaking with various professionals we found that the complexity of Photovoltaic systems comes from the installation and design of each specific system or array.

One main issue that arises when finding the right solar array for your building is the usable roof space.. There are several factors that play into this estimation. The first factor that may be the most important is the one of sunlight. For a roof to be a good candidate for a photovoltaic system, the roof must have an unimpeded view of the sun throughout the day. The orientation of the roof is also important because as the sun rises in the east and crosses the sky to set in the west, our orientation in the northern hemisphere puts the sun at a southern angle to the building. When a building has a flat roof, like buildings one and two in our complex, the solar panels must be tilted so that the axis of tilt is orthogonal to the south. As you can see in Figure 10: Flat Roof Array Figure 10 the panels on the flat roof are tilted towards the southern side of the building. The Array shown in Figure 10 are a typical ballasted system meaning that the entire array is held to the roof by weight alone. This method allows for the system to not only to be easily maintainable but also have little impact on the structural integrity of the roof.



Figure 10: Flat Roof Array (Solar Flair, 2009)

Because buildings one and two are the highest and face the south without any shadows during the day they are ideal for solar arrays. After speaking with a photovoltaic specialist we found out that when estimating the usable roofspace in square feet one must give a 10 foot perimeter around the building so that the panels are protected from the wind. As you can see in Figure 11: Roof Space Estimation Figure 11 we used arial photos of our building to estimate the usable roof space for buildings one and two shown in yellow and purple respectively. We also made an estimation for building 28, shown in green. These roof space estimates were done using an online tool called Roof Ray (Ray, 2009). The Estimates for the three buildings are as follows. Building one, shown in yellow, is about a 38kW system. Building two, shown in purple, is about a 63kW system and finally building 28, shown in green, is about a 112kW system. These estimates are based on surface area only and do not consider possible layout issues so we contacted got a better estimate from a professional.



Figure 11: Roof Space Estimation (Ray, 2009)

One specific professional that we spoke with was Matthew Arnor, president of Solar Flair, Inc. After providing him with more information about our building he was able to give use

better estimates for buildings one and two. Those estimates were 17kW and 68kW respectively. Based on a 15 degree tilt, the two ratings are subject to change with different tilts.

The system on building two, which is about 68kW, would cost about \$512,000, however there are huge rebates for the installation of PV systems. Also mentioned by Mr. Arnor was the fact that there are tax rebates of about 30 percent. For the half million dollar system on building two, only about ¼ of that would be left to be paid for after the generous rebates. With systems such as PV the pay back is enormous and would be in the 5-7 year range. Because the Solar Flair company deals with all of the rebates when installing a solar array Matthew Arnor said that he would be more than willing to help with any further design questions

4.3.4 Solar Hot Water

After speaking with solar professionals we discovered that solar hot water heating takes a very large amount of roof space to generate any significant amount of heat. The heat also must be stored in a water tank which ends up losing some energy because of the insulation needs. Another problem with solar hot water heating is that the demand for hot water in a residential building generally is greatest in the morning or at night, whereas the greatest heating potential occurs during around noontime.

4.3.5 Geothermal

Although there was only one interview conducted on geothermal, Martin Orio, a geothermal specialist, gave a substantial amount of information. He explained that there are many things that need to be taken into consideration when looking into a geothermal system. Most importantly, he said that one needs to know the load of the building or how much energy the building will consume. The load of the building is calculated in units of tons. A ton is simply a literal ton of land mass and relates to the amount of heat that can be extracted from that much landmass. Mr. Orio also explained that for a building like ours one could estimate the load of the building to be about 400-500 square feet of floor space to 1 ton of landmass. He explained that if you install 1,500' x 8" pores, 50 feet apart from each other, they will provide about 25 tons of energy each.

Another important question to ask is what is the makeup of the soil where the system will be installed? This is important because one needs to know what is underneath in order to know

what type and size of system needs to be installed. Although he doesn't work in the Worcester area, Martin Orio believed that in the Worcester area one will probably hit bedrock after drilling about 50 feet down. Even though this may sound bad, Martin Orio insured us that bedrock is actually beneficial. Bedrock will act as a personal case for the well and will give it support, however, the drilling will be harder to accomplish.

During the interview, we also asked Mr. Orio if he could give us an average price of each system. Since we did not know the load of the building at this time, this was difficult for him. He said that the price had a lot to do with the kind of system is installed. If our sponsor looks into a closed loop slinky system then the loops will have to be 450 feet down, 20 feet apart and will cost about \$3,500 per ton of energy. For a vertical closed looped system, there should be 3 or 4 columns 50 feet apart, which will cost about \$2,500 per ton. There is also a price for each ton on the outside and inside. On average the cost per ton of energy on outside is between 2,500 and 3,500 dollar, and the cost per ton of energy on the inside is between 4,000 and 7,000 dollars. In total, our sponsor will be looking at a total cost between 6,500 and 10,000 dollars per ton of energy. To conclude the interview, we asked Martin Orio if in his professional opinion, does he think geothermal is a good system to use for our building. He responded with "Absolutely, with no question in my mind."

4.3.6 Rooftop Garden

Our study into the feasibility of a rooftop garden on 93 Grand provided our group with a wealth of information about rooftop gardens. We combined research and information we received by interviewing Jared Markham of Weston Solutions, which was the company that designed the rooftop garden on WPI's West Hall, to gain a better understanding of the potential of installing a rooftop garden into our project.

Rooftop gardens are broken into two types, extensive and intensive. Intensive green roofs have an 8 inch soil depth and would allow for recreation on top of the garden itself. This intensive rooftop garden, however, would have a weight loading that starts at 40 pounds per square foot. Extensive green roofs, on the other hand, utilize a soil depth of 4 inches, with a weight loading of 18-22 pounds per square foot in addition to any snow load. This type of rooftop garden is much more cost effective and will not require as much maintenance as an extensive green roof. Companies often also offer extensive green roofs at a depth of 2½ inches of

soil depth as well which will provide a lower weight bearing on the roof but will also not retain as much storm water as deeper rooftop systems.

Finally, the costs of a green roof system will be extremely important in ultimately deciding if a green roof system is a sustainable technology that Main South wants to invest in. Green roofs typically cost between \$10-20 per square foot based on the size of the rooftop garden. The larger the garden becomes, the cheaper it will be per square foot. This cost will also potentially be changed based on plant selection.



Figure 12: WPI East Hall Rooftop Garden (WPI News Releases, 2008)

4.4 The Binder

The binder has resulted as a very effective way to centralize all the information we have collected. We have included seven sections in the binder, the first section starting with the meeting minutes with our sponsor. The second section holds all of the minutes from each phone interview we conducted so our sponsor can refer to them when planning to start the renovation of the Crompton Knowles building. In the third section our sponsor will find all the information that has to do with the Design Charrettes that took place on the 10th and 11th of December. We have supplied the Agenda for the Professional Charrette, the attendees list for both charrettes and their contact information. We have also included the report and summary that our sponsor had created after the charrettes took place.

In the fourth section of the binder we have compiled all of the building information. The soil map is included along with a brief description of the soils found in our area. Our team has also attained a sewer system map of our community and also a larger map covering more of the

city. Section five will contain pictures of the building with a brief description of each. Section six will contain all of the demographic and community information. A very detailed map of the community is included and can be seen in Appendix A. We have shown a map of the zip code zone of 01610 and a closer look into our community, showing the boundary streets. Furthermore, we have included all the demographic information with graphs for easier understanding. A list of local apartments is included with detailed information about the individual apartments and the price for renting. Following this is a list of apartments for sale in the area, their detail information and also a list of eco-friendly apartments throughout Massachusetts. Within this section there is also a list of green child care centers around Massachusetts, and an Eco-Healthy Child Care Checklist from the Oregon Environmental Council.

In the last section of the binder is about the price point build-outs and local suppliers. We have made a list of green products and their pricing per square foot. Following this, is a list of products with the level of “greenness” of each, along with where you can find more information about each product. Additionally, there is a list of local suppliers in the area accompanied by a map showing their distance away from our community.

This binder will provide our sponsor with a very well organized location to find all the information about this project. This will also be a place where our sponsor can keep all the future information gathered.

Chapter 5: Implications

After presenting our results in Chapter 4, we will discuss the implications in Chapter 5 and provide our recommendations. Within this section we will discuss how our sponsor can use the information we collected and our recommendations for the building. The community section discusses how and why the community needs the renovation of this building. The building information follows and will give our suggestions of the site plan. The subsequent section on technology will discuss the feasibility of each technology and what we suggest should be implemented on the building. We will end the section with a discussion about the binder.

5.1 Community

The community will be affected most by this renovation, so this section will discuss why the community is in need of a change and provide our recommendations on a green child care center being established within the building. We will also touch on the subject of the real estate market within our community and if we believe that this type of renovation is economically feasible.

5.1.1 Community Mapping

Our goal in creating a community map was to identify the local retailers in the Main South Community. By identifying each business we hoped we could help assist the localized economy by promoting their services by way of a mall styled map with each business categorized by the service they provide. By promoting the local businesses we hoped that people living within Main South would try to help maintain the small business owners and prevent money from leaving the area by shopping outside of the area. In the same sense we could hopefully encourage potential tenants of 93 Grand to do their shopping and business within Main South by possibly posting the map within the building.

Creating our map also was a valuable tool in terms of identifying what types of businesses and retailers are currently within the Main South community and which type of potential businesses 93 Grand could sell to, based on the current needs within the community. For example, we were able to identify that there were no child care centers within the community, making a child care center a feasible addition to the 93 Grand project.

5.1.2 Green Child Care

From our research and case studies we have been able to conclude that a Green Child Care center is a great idea from this project from a number of perspectives. A child care center within the community does make sense in the community since it could potentially sell towards family with a low income that may need both parents to earn an income as well as people from the Clark University area. The issue of making it a *green* child care center also is a viable option, since “Eco-Healthy” child care is gaining popularity throughout the country, and makes sense seeing as though it is a center that cares for the well being of children. Finally, as proposed in the documentation we received from Pagano Lamoureux and Associates, building 35 stands as a perfect fit for the creation of a child care center.

5.1.3 Demographic Data

The demographic data is a very important aspect of this project because it brought meaning and feasibility to the renovation of 93 Grand. The main reason for the renovation of this building was to provide affordable housing to the neighborhood, and in order to provide recommendations we first had to find if there was a need for housing in our community. After collecting demographic data from the U.S. Census Bureau, we found that only around 40% of our community is housed as of 1999. More current information is not available at this time, but it can be assumed that our community housing percentage has not been fulfilled due to the economic situation at this current time. We found this information by multiplying the total number of household units in our community by the average family size in our community. This gives us an estimate of 4,566.48-4,995.6 people that are housed in our community. Comparing this information to the total population, which is between 11,949 and 12,686, shows us that only between 38.1 and 39.4 percent of our community is housed as of 1999. This is an estimate, taken from the demographic data found on the U.S. Census Bureau for the year 1999.

After confirming that our community is in need of housing, the renovation project makes much more economic sense. Furthermore, the demographic data supplied the percentage of household units that are renter/owner occupied. This information lead to our recommendation that our sponsor should not only supply the community with housing but they should lease the apartments they plan to offer. Furthermore, the apartments should be able to house around the average family size, which is between 3.59 and 3.62 persons for our community.

The last important aspect based on the demographic data collected, is the median income within our community. Since the median family income is \$22,915 for our community, affordable housing would be the best option to implement in the building. Nearby our building are the University Lofts and Royal Worcester Apartments, which are not affordable housing. This proves further that affordable housing is the best option.

In conclusion, our recommendation for the Main South CDC is to provide affordable housing for the community. Furthermore, they should recall the average family size in their community and lease apartments close to these averages.

5.1.4 Real Estate Research

Our conclusions produced from the real estate research and interviews we conducted produced two strong conclusions based on one aspect, funding. This type of green renovation project does not make economic sense unless it has appropriate federal grants and funding for green technology and sustainable renovations. There is an obvious housing need in the Worcester community especially with respect to low-income type housing in the Main South area. The potential tenants for this type of project are highly unlikely to be attracted to the building for its sustainable qualities, but rather due to the fact that it sells to low-income families in the area. However, if creating a sustainable building is an avenue to provide funding along with the benefits the technology itself will provide, it makes economical sense to pursue this type of project.

If the project was not receiving funding based on the incorporation of green materials and technologies, then our recommendation from a real estate and economic standpoint would be to incorporate conventional building materials which would come at a cheaper initial cost. This would provide for the ability to lower the housing price which would be otherwise covered by alternative funding. In our interview with William T. Lee he stressed that the clientele that would be willing to spend more money to live in this type of refurbished green apartment instead of a regular apartment, likely would not be willing to live in the Main South area

5.2 Building Information

Within this section, we will provide our recommendations for the site plan of the building and what we believe our sponsor should implement into each building. We will describe the use

of the local suppliers list and why it is helpful for our sponsor. The price point build-outs will stand as a reference guide on what green material could be implemented in the building, along with their price and product information.

5.2.1 Ground and Building Plans

The ground and building plans gathering aspect of our project does not necessarily bring our group to poignant conclusions; however it was still an important exercise for us to gain a complete understanding of the building and its condition. It will also greatly assist Main South in the future since all the documents we have collected will be compiled into the binder which will be a centralized location with all the buildings information readily accessible.

Using the future land use plan that was included in the report we received from Pagano and Lamoureux Associates shows that the apartment building plans that were in development stages in the area have now been completed. Typically, having other apartments in the same area could hinder each apartment's ability to find clientele. However in our mixed-use building report, having large populations of people very close by means numerous potential buyers within easy walking distance. Considering that 93 Grand proposes affordable housing, unlike the Royal Worcester Apartments and the University Park Lofts, means that 93 Grand likely will not lose potential tenants to the other two apartment projects within the area.

After reviewing these plans, we have been able to come to some conclusions as to the potential future uses of the building. One consensus agreement we have come to regards possibly knocking down both buildings 28 and 28A. There are city ordinances on projects regarding necessary parking, and it is a necessity for both the residents of the proposed apartments and for potential clients of the proposed businesses from the project. Taking into account that building 28 is a steel framed building, it could potentially be used as a parking garage type structure. Also saving the saw toothed roof may turn into a priority in the project and this parking garage idea would allow the roof to be reconstructed and saved. However, parking is going to be a definite issue with this project and with buildings 1 and 2 being in the best condition the obvious choice based on size and condition would mean the demolition of 28 and 28A. It is an issue that you will have to deal with as the project moves forward, and the future use of 95 Grand and the other empty lot on the opposite side of Grand Street could allow for parking, however until the future of both those parcels of land are determined the most viable option is where building 28 stands.

5.2.2 Researching Green Suppliers

Much like the ground and building plans, the green suppliers list will stand as a reference for ordering green building materials and contacts for green technologies as Main South moves forward in their project. Once construction is set to begin Main South, or their hired contractor, can contact these suppliers for materials, or request where they can find similar materials in the area. Ideally in the near future, when Main South sets out to begin construction on this project green building materials will have become even more common and accessible to contractors and construction companies in the area, making the materials cheaper and easily attainable.

5.2.3 Price Point Build-Outs

Our work dealing with the price point build-outs gave Main South a glimpse of the average price per square foot for many potential green materials that could be included in the project. This listing can be used as a starting point and reference for deciding what types of materials will be installed into the apartments and condos of 93 Grand. They can use the lists which have been organized into categories such as cabinetry, countertops and flooring as suggestions for potential materials based on their category. Included in this listing are sustainable paint and lighting options, as well a low-flush, dual flush and composting toilet options. These build-outs will assist Main South in categorizing and deciding what type of materials they intend to include in the building. However, with green building being such a new development within the past few decades, there are bound to be new materials and adaptations within the upcoming years and it will be important for our sponsor to stay current in the fields of green technologies. This list will be formally included in Main South's binder along with photographs of all the materials included in each build out (+1, +2 and +3).

5.3 Technology

The main objective of our project is to provide our sponsor with recommendations of green technologies that are feasible for the Crompton Knowles building. After researching each technology and examining the results of our methodology, this section will provide a discussion about each technology and present recommendations of which technology should be implemented on the building. Our recommendations were developed after extensive research, interviewing professionals and considering the cost/benefit analysis in order to provide our sponsor with the most feasible alternative energies to apply.

5.3.1 Storm water

When our research is applied to our project the stormwater management plan for the 93 Grand project can be viewed in two parts. The best storm water management plan for our building will be a rooftop garden. The rooftop garden will absorb most all of the rain from storms and prevent it from running through downspouts to the ground and creating true storm water. If a rooftop garden can be installed on the roof of 93 Grand, the need for a storm water management plan on the ground is not a necessity. However, if a rooftop garden is not a possibility because of structural problems with the building or the cost associated with that type or project, then the building would need a storm water management plan.

The most obvious piece of a stormwater plan would be the incorporation of landscaping that would utilize native, deep rooted plants that would ideally absorb much of the water produced by a storm. In addition to landscaping the next feasible option would be to create an infiltration trench that could run along the exterior of the buildings grounds. The trench is a cheaper alternative than other solutions which would greatly assist in managing storm water. The last option that could be looked into further would be the installation of permeable pavement. However in our cold climate and with cars potentially being parked for long periods of time, this may not be the best option. It is also a more expensive option than an infiltration trench and would not be as successful in managing the areas storm water.

By taking these ideas further with respect to the project, a possible plan could involve creating a type of park where the current parking lot of building number 35 sits. This park could incorporate stormwater managing landscaping while keeping the large tree in place per request of our sponsor. This type of park would suit the tenants, workers, and possibly even the potential daycare center. The proposed infiltration trench could run on the outside of the proposed park along Grand Street, as well running between the parking lot where the current building number 28 stands and Wyman Street. With this proposed trench running all along the exterior of the project, the stormwater of the area should be handled while potentially adding to the aesthetic value of the project. The infiltration trench would also negate the necessity for installing permeable pavement in the parking lot.

5.3.2 Greywater

There are many possible solutions to reusing greywater in a project similar to ours. The best potential option for our project may not be the installation of a large greywater system that covers the whole building, but rather a system that deals with individual bathroom sinks that lead into a small treatment tank that, in turn, connects to the toilet. This option (AQUUS Gray Water System) is a cheaper and more reasonable product that could be considered as the project moves forward. It will not require the water tanks, treatment facilities and piping system required for a more extensive greywater treatment system. A conclusion that Main South may come to however, after reviewing their energy needs and budget may be that a greywater system is not necessarily the best option for this project. Investing into technologies such as geothermal and solar seem to be more feasible and cost saving options.

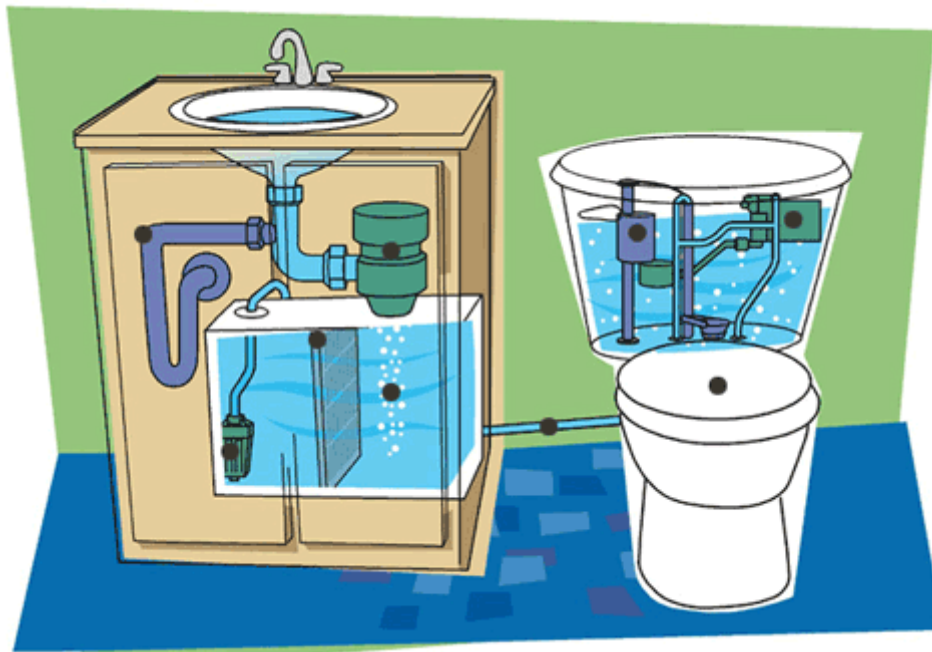


Figure 13: AQUUS Greywater System (Charles and Hudson, 2009)

5.3.3 Photovoltaic

Buildings one and two have the greatest possibility for a photovoltaic system because of they are the highest buildings in the area and because of that there are no other buildings that cast a shadow on the roof of the building. We also believe that Building two has the best setup for a solar array because the building is closer to rectangular which makes for a more efficient use of

roof space. Also because the roof is flat a low tilt ballasted system can be used making the installation of the system non penetrating and thus won't affect the roof's ability to keep out water. Building one, while still a great candidate for a photovoltaic system, may be better suited for a green roof. Photovoltaics are very efficient with energy production and waste because the systems are guaranteed to last for 25 years and there is no reason why they wouldn't last longer. There are no moving parts to the solar panels and as long as the cells are well sealed weathering is not an issue. Also the energy that is created goes directly to use either in the building or gets fed into the electrical grid so that others can use it. When the electricity gets fed into the grid this is called co-generation and it is a principal that should be employed by all energy production devices especially ones that produce massive amounts of energy. The reason that co-generation is so efficient is because energy in one form whether it be electricity, heat or motion, is transmitted most efficiently if it doesn't have to change forms. In a photovoltaic system electricity is produced and, once inverted to alternating current, it is most efficiently used right away in the grid because the other method of storage is batteries where energy is lost in the charging process due to heat.

Also a photovoltaic system is something that should be incorporated into this renovation project because for one it makes economic and environmental sense. Firstly the photovoltaic system that would be installed on building two would have a pay back of about 5-7 years which is a good investment because it will end up cutting electrical costs dramatically. These savings will be passed on to the people living in the building which reduces their living costs making living more affordable which is a goal of this project. Secondly, the installation of a photovoltaic array decreases the building's dependence on fossil fuels and thus reduces the carbon footprint of the building, making it more sustainable and green.

5.3.4 Solar Hot Water

Solar heat is something that is evenly dispersed throughout an area. To harness the power of the sun a large area must be used to collect the sun's energy. In the case of solar hot water heating this holds true. Because there isn't much of a footprint for our building that is open space except for the roofs only the roofs are available for solar heat collection. However a solar hot water collection system is not practical to apply to our building because there isn't enough roof space for our building to generate enough energy for the high population density of the building.

A solar hot water heating system is also not practical because the roofspace could be better used for either a photovoltaic system or rooftop garden. Also the use of a geothermal heating system would make a solar hot water heating system unpractical because all of the hot water would be generated by the geothermal system.

5.3.5 Geothermal

Geothermal energy is a great heating alternative and we believe it is very feasible for the 93 Grand building. After investigating this system further and conducting an interview with Martin Orio, we recommend this system over any other heating alternative available. Since there is not a large footprint for this building as of now, a vertical system would be the best option. Furthermore, when the renovation process takes place the Main South team will be able to make a decision between a vertical closed loop system and an open loop system (uses a well). Since there is already a well on the property, they can also research further to see if the well could possibly be used as the injection well for the system. If this well cannot be used for the system, it could still be helpful in determining between a closed loop and open loop system. With this well in place, an expert in this field will be able to find out how much water the well is being supplied. To find this information, the expert can run an irrigation pump which will show how many gallons of water per minute the well is producing. With this information, the Main South CDC can see if using an open looped system would supply enough water for the energy used by the building.

After finding this information, if an open looped system verifies unfeasible, the vertical closed loop system would be the best option. With a vertical closed loop system, the pores are about 1,500 feet deep and about 8 inches in diameter, each column providing around 25 tons of energy. While interviewing Martin Orio, he estimated that of a building of our size would need around 100 tons of energy. Therefore, to supply 100 tons of energy there would need to be around 4 or 5 columns installed, each being at least 50 feet apart. Our team believes that this is the best option for the building, only if the well already established on the site deems unfeasible. Since this is a sustainability project, the Main South team should incorporate as many reusable materials as possible, including this already drilled well if feasible.

5.3.6 Rooftop Garden

A rooftop garden is a definite possibility for the 93 Grand project. However, prior to looking into potential rooftop gardens, Main South must have the roof structure reviewed by a structural engineer to ensure that the existing building can withstand the added weight that a green roof would bring. If the building is deemed structurally sound, an extensive green roof is clearly the best option for 93 Grand.

This type of system has several advantages over an intensive green roof especially with our specific project in mind. First and foremost, an extensive green roof is the most cost effective system. Additionally, the weight bearing on the roof is about half that of an intensive green roof. Finally, an intensive green roof requires much less maintenance, which will be important considering that this building will be a mixed-use building and will not have a staff that will maintain such a garden. With respect to storm water, if an extensive green roof is installed rather than an intensive green roof, which provides for more successful storm water management, Main South may want to consider other storm water management systems on the ground which would not be a necessity if an intensive green roof was installed.

Other possible options in terms of rooftop gardens would be to put the garden on building number 28 which is steel framed and likely able to withstand a lot more weight than buildings 1 and 2. However, since the roofs of both building 1 and 2 will likely need to be replaced, that may be another reason that a rooftop garden is a good option since they usually outlast conventional roofs, in addition to lower the heat island effect and creating better interior insulation. Another possible avenue would be to identify the stronger portions of either building 1 and 2 for the green roof to be located on, leaving the roof section that are not as structurally capable to the lighter photovoltaics. Ultimately, if a rooftop garden is not a possibility due to structural or economic restrictions a white roof is always a possibility.

5.4 The Binder

This binder holds all of the information and research we have collected throughout this project. Our recommendation is that the Main South CDC continues the upkeep of this binder and makes full use out of all of the information incorporated within it. We have provided them with unused sections that they can use as they please, along with a set of sheet protectors so all of the information can be found in one, well organized area. When the renovation process takes

place, we suggest that they bring this binder when talking to experts. Furthermore, if they plan to have another IQP team work further into this project, this binder would be a great resource for the team to get a sense of the building and the kind of project they are working with.

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Appendix A: Community Map



	Places to Eat
1	Dunkin Doughnuts
20	Danny T Murphy's
22	crescent Café
26	Kotsai Pizza
35	Genes Place
54	Diamond Pizza
	Tiem Vang
60	Khai Thue
	Nhu Hgoc
67	Hong Kong (food)
	Giocha thu Dic Vietnam Fast Food
74	
77	Special in Oriental Food
	Best Chinese Resturant
83	Moynihan's Pub
89	Huang Vu
90	Fantastic Pizza
100	Mohanan
103	Uncle Sam's pizza
	Main Attraction

	Brisa tropical Resturant
	Saigon Resturant
112	McDonalds

	Schools
29	Canterbury Street School
36	University Park School
	Goddard School of Science and Technology
38	St Peter Central Catholic School
66	

	Places of Worship
2	Catholic Charities
5	Second Baptist Church
13	Casa De Oracion
	Worcester African Cultural Center
15	
23	Vietnamese assembly of God

25	Brazilian assembly of God
37	St Mary's Episcopal Church
41	holyName of Jesus Rectory
67	La Luz Del Mundo
	New Life Temple
	Iflesia Jesucristo Fuente De Gracia, Inc.
76	Tempio Adventista
84	The Woo- An art Christian Church- Pilgrim Congregation Church
99	St. Peter's Catholic Church
101	Church of God
111	Liberia Christiana

	Grocery Stores
26	Atlantic Market Seafood
27	San Miguel Grocery
28	Randell Package Store
60	Kumasi Supermarket
75	Family 88 supermarket
77	Hatien Market Oriental Food + Gifts
96	Main South Market
102	Tedeschi Food Shops
111	Santiagos Market

	STORES
60	Habilab Department store
77	Super Discount

	SERVICES
3	Real Court Reporting
4	Alfred Roy and Sons Funeral Home
6	Sun Bridge Care and Rehabb Hammon House
7	New Method plating Inc.
8	Providence/Worcester Railroad

9	David's service Center
10	Stoney Collision Center
11	Cogswell Sprinkler Company Inc.
12	Insight Neuroimaging Systems
14	Lusignan Bros Inc
16	Leader Sign Inc.
17	Hi-Tech Auto
18	Pioneer Oil Company
19	Lopez Auto
21	Kelly's Auto body/Central Auto Works
22	Allure Barber Shop
24	Baker Fire Equipment Company Inc.
26	Ethnic Beauty International
30	Us Reflector
31	People's Choice Hair Center
32	Kesseli & Morse Company
33	GCM Auto
34	Joe Pes Sports
39	Communications Technology
40	Son Redemption Center
43	Micro Tech Manufacturing
44	Terminal Whare house
45	F and R Office Products Inc.
46	Furniture Plus
47	Sclamos
49	Mal's Auto
50	ANC Tool
51	G & V Auto Repair
52	Bishop BJ Flanagan Center
54	Triana studio
	Professional Cuts
	Job Finder
60	Nau Beauty Salon
	Lams Bridal
	Chuyentien
65	Family Dental Center
67	Happy Laundomat
71	Main South CDC
	Neighborhood Alert Center

73	Cultural Center Hrisohoorafiton Alexander the Great, Inc.
77	New England Nails Supply
82	George's Flowers + Gormet Basket
85	MacShawson Insurance
	Kieth Plub Heat
	Mathason Law Office
	GTBW Therapy
90	WCUW Radio
92	Clarck University book Store
93	Carlito's Barbershop
94	Unique Nails
	Music Plus

97	La Canastilla Ideal
	China Lantern
103	Riveria Nails
108	The Ward Building
109	Bones + Flowers
110	Xuansttair Salon

	PLACES OF INTEREST
42	University Park Lofts
48	The Royal Worcester Apartments
53	Boys and Girls Club

Appendix B: Demographic Data Collected

	Our Community	Worcester 01610	U.S.
General Characteristics			
Total Population	11,949 - 12,686	23,773	
Median Age	27.5 - 28.9	25.2	35.3
Race (percent)			
White	41.1 - 47.6	65.4	75.1
Black or African American	9.4 - 11.3	9.2	12.3
American Indian or Alaska Native	.8 - 1.3	0.7	0.9
Asian	8.8 - 10.8	7.4	3.6
Some Other Race	22.8 - 28.4	12.6	5.5
Two or More Races	6.1 - 6.2	4.8	2.4
Hispanic or Latino	44.2 - 48.0	23.8	12.5
Household Population (number of households)	1,152 - 1,240	19,919	
Avg. Household Size	2.71 - 2.84	2.58	2.59
Avg. Family Size	3.59 - 3.62	3.32	3.14
Total Household Units	1,272 - 1,380	8,455	
Owner-Occupied Housing Units	12.9 - 15.5	21.7	66.2
Renter-Occupied Housing Units	84.5 - 87.1	78.3	33.8
Vacant Housing Units	9.4 - 10.6	8.8	9
Social Characteristics			
Population 25 years or older			
High School Grad or Higher	50.5 - 56.0	63.3	80.4
Bachelor's Degree or Higher	13.8 - 16.4	12.4	24.4
Speak a language other than English at home	54.9 - 61.3	40.2	17.9
Economic Characteristics			
Median Household Income in 1999(dollars)	23,029 - 25,382	26,152	41,994
Median Family Income in 1999(dollars)	22,917 - 23,696	30,383	50,046
Per Capita Income in 1999(dollars)	13,170 - 14,277	12,569	21,587
Families Below Poverty Level (percent)	38.4 - 38.6	25.0	9
Individuals Below Poverty Level (percent)	35.8 - 40.5	30.0	12
Housing Characteristics			
Single-Family Owner-Occupied Homes			
Median Value (dollars)	67,500-83,300	99,300	119,600
Median of Selected Monthly Owner Costs			
With a Mortgage (dollars)	863 - 980	949	1,088
Not Mortgaged (dollars)		328	295

Appendix C: Local Suppliers

Local Green Suppliers in Massachusetts

Bradco Supply Corporation (marked as A on map)

<http://www.bradcosupply.com/index.asp>

2 Sherman St. Worcester, MA

508-792-1200

Description taken from their website:

As a leader in the building products distribution industry, Bradco Supply is dedicated to supporting environmentally conscious, or “Green,” building practices.

For a list of green products please visit:

http://www.bradcosupply.com/green_products.aspx **Total**

Plastics Inc. (marked as B on map)

<http://www.totalplastics.com/>

81 Lafayette St. Worcester, MA

508-365-2300

Green Statement taken from their website:

Description:

Total Plastics and the Environment

Total Plastics, Inc.TM and its suppliers are committed to making the world a better place to live through plastics technology. Plastics possess the following benefits, which better our lives with minimal environmental impact.

To see complete description please visit: <http://www.totalplastics.com/products/357>

To see a list of products please visit: <http://www.totalplastics.com/products/category/45>

Grainger (marked as C on map)

<http://www.grainger.com/Grainger/wwg/start.shtml>

209 Brooks St. Worcester, MA

508-853-7300

Description taken from their website:

According the U.S. Green Building Council (USGBC), of which Grainger is a member, 2008 was the year when green building became inevitable, due to the U.S. recession. USGBC is a non-profit organization composed of leaders from every sector of the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work.

For a list of products please visit: http://www.grainger.com/Grainger/static/rc_green.html?xi=xi

Bettencourt Green Building Supplies (marked as D on map)

<http://www.bettencourtwood.com/index.html>

Stocks in Medford, MA

800-883-7005

Description taken from their website:

Dedicated to providing quality green building materials to designers, architects, contractors and homeowners on the East Coast, Bettencourt Green Building

Supplies offers innovative products at affordable prices. Extensive research and first hand experience working with new materials help us to provide elegant and appropriate alternatives to many of the environmentally damaging choices currently available in the industry.

For a list of products available please visit:

http://www.bettencourtwood.com/products_main.html

Green Depot (marked as E on map)

<http://www.greendepot.com/greendepot/default.asp>

100 Fallon Road Stoneham, MA

781-914-3300

Mission Statement taken from their website:

Make "green" building and living solutions accessible, affordable and gratifying.

For a list of products please visit:

http://www.greendepot.com/greendepot/dept.asp?dept_id=500&s_id=0

ReStore (marked as F on map)

<http://www.restoreonline.org/>

250 Albany St. Springfield, MA

413-788-6900

They accept donations from usable but unwanted home improvements and sell them to the public. They sell used and salvaged materials along with unwanted surplus stock from other industries.

Mission Statement taken from their website:

- Reuse valuable materials
- Make home improvement affordable for more people
- Create local jobs and provide job training

The ReStore received grant funding to help cover costs during the first few years of operations, but is now self-sustaining through the income created by sales.

For common materials please visit: <http://www.restoreonline.org/common.htm>

Battic Door Home Energy Conservation (marked as G on map)

<http://www.batticdoor.com/>

Mansfield, MA

508-320-9082

Description taken from their website:

We manufacture Home Energy Conservation Products that save you money, reduce your energy bills, and improve the comfort of your home. We sell direct - buy from the manufacturer. Fireplace Plugs, Whole House Fan Shutter Covers, R-50 Attic Stair Covers, R-42 EZ Hatch Attic Access Doors, Dryer Vent Seals, Radon Test Kits, Air Conditioner Covers, Insulated Switch Plate Covers Our products SAVE YOU MONEY ON YOUR ENERGY BILLS by reducing drafts and air-leaks around often overlooked "holes", including the attic stairs, the whole house fan, the fireplace, the clothes dryer, and the bathroom exhaust fan. By sealing these air leaks, our products reduce cold drafts and heat loss in the winter, as well as air-conditioning loss in the summer. Our products conserve energy,

lower your utility bills, reduce noise and pollutants, improve indoor air quality, reduce the chance of ice dams and attic mold, and improve the comfort of your home. We ship direct to customers, and sell in bulk to builders, weatherization contractors, and distributors.

For a list of products please visit: <http://www.batticdoor.com/store.htm>

De Vries Building Supply Inc. (marked as H on map)

<http://www.devriesbuildingsupply.com/>

21 Berkshire School Rd. Sheffield, MA

413-229-8777

Mission Statement taken from their website:

We offer traditional building materials, as well as some innovative alternatives to common construction products. Our goal is to help educate the homeowner, and professional contractor as to the application and installation of alternative products to further promote the greening of the construction industry. As homeowners, we are always trying to come up with ways of improving our homes. We hope each improvement will enhance the value of our investment, whether it be new state-of-the-art windows and doors, earth-friendly cotton insulation, or just a new coat of paint. Whatever we change will impact the whole.

For a list of products please visit:

<http://www.devriesbuildingsupply.com/secondary/greenProducts.htm>

‘g’ Green Design Center (marked as I on map)

<http://www.ggreendesign.com/>

28 Bates Road Mashpee, MA

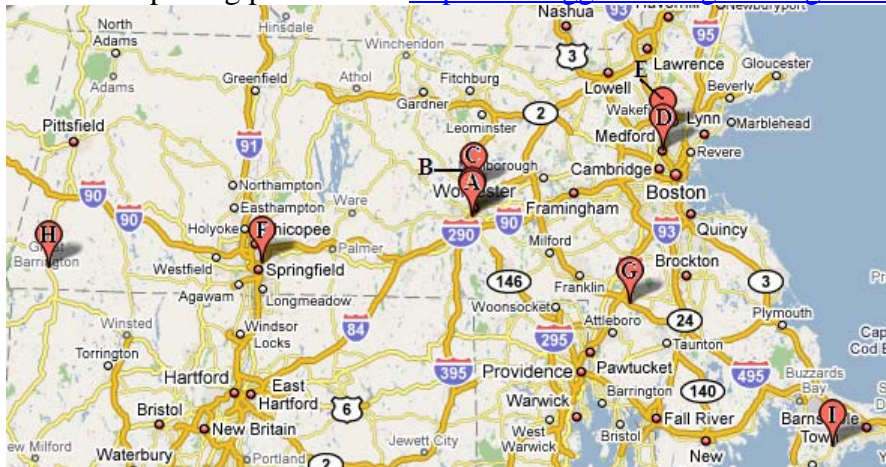
508-477-7988

Mission Statement taken from their website:

Our focus is to provide you with everything needed to create green, sustainable environments that are both beautiful and responsible to our earth.

We do this through the **‘g’ Green Design Center’s** showroom, a place where clients and visitors can learn about, explore and purchase not only the materials they need to create a green building, home or business, but a multitude of home accessories, organic clothing and body care products.

For a list of products and pricing please visit: <http://www.ggreendesign.com/green-products.htm>



Green Suppliers in Connecticut

The Center of Green Building (marked as J on map)

<http://www.centerforgreenbuilding.com/>

3380 Fairfield Avenue Bridgeport, CT

203-382-0774

Mission Statement taken from their website:

The Center of Green Building is taking a logical approach to making your home a sustainable place. We believe every person makes a difference. Our mission is to provide products that are safe for the people manufacturing them, safe for the people exposed to them and safe for the environment in which we share.

For a list of products please visit:

<http://www.centerforgreenbuilding.com/MediaArticles/CFGBProductList.pdf>

For pricing please visit their website listed above.

AlwaysBuildGreen.com (marked as K on map)

<http://www.alwaysbuildgreen.com/index.htm>

167 Main St. Norwalk CT

203-846-6060

Their Philosophy taken from their website:

We believe the build environment is a reflection of the relationship we have with our planet. As both designers and builders, we feel responsible to participate in the growing consciousness about how our actions and life styles affect the environment. Therefore, we strive in our design, planning, product choices and construction to provide simple, functional, healthy structures that are earth friendly, and based on sound use of the world's resources.

For a list of products please visit: <http://www.alwaysbuildgreen.com/greenproduct.htm>

Green Supplier in New Hampshire

Your Home Your World

138 N. Main St. Concord, NH

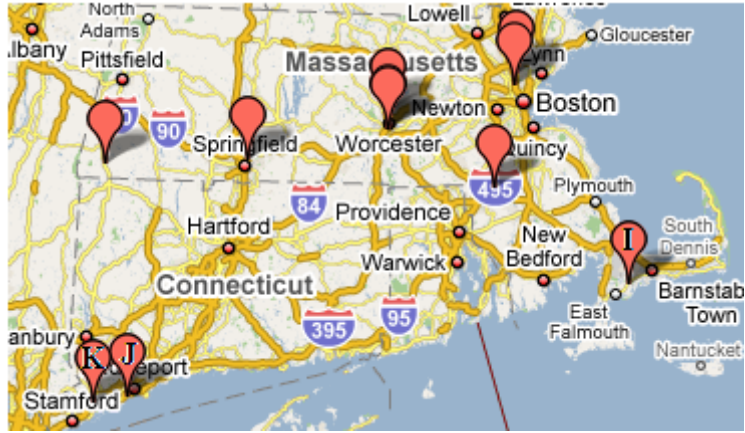
603-223-9867

Mission Statement taken from their website:

Our mission is to provide options for people who are concerned about the environment inside and outside of their home, but do not want to sacrifice beauty, comfort and convenience. We support businesses that promote positive social and environmental change while producing high quality products.

For a list of products please visit: <http://www.yourhomeyourworld.com/products.html#home>

Recommended



Appendix D: Price Point Build-Out Materials

Green Materials for Price Point Build-outs

Flooring

- Bamboo \$4-8/sf
- Green Capet \$4/sf
- Cork \$3-6/sf
- Wood \$3-6/sf
- Linoleum \$4/sf

Note: Bamboo is not a locally grown material, so there would be additional shipping costs. Cork sealers are harmful to the air quality. Wood must be Forest Stewardship Council Certified.

Cabinetry

- Wheat Grass Cabinets
- Bamboo Cabinets
- Breathe Easy Cabinets (Brand)
- Wood

Countertops

- Recycled Plastic \$50-100/sf
- Wood Butcher Block \$50-75/sf
- Laminate \$25-50/sf
- Ceramic/porcelain tiles \$5-20/sf

Bathroom Walls

- Stone \$5-65/sf
- Terrazzo & Concrete \$20-50/sf
- Glass Tile \$15-40/sf
- Ceramic Tile \$5-20/sf

Toilets

- Low flow \$150+
- Dual Flush \$300+
- Composting \$1,500-2,000

Paints and Stains

- Auro Paint, Stain
- AFM Naturals

Shower Head & Sink

- Low Flow

Lighting

- CFL's

Price Point Build Outs

+ 1 Build Out:

- Flooring – Green Carpet & Linoleum
 - http://www.truehardwoods.com/i//shaw_carpet_1.jpg
- Cabinetry – FSCC Wood
 - http://www.hdwoodworking.com/template_Cabinets%20plus%20dining%20room.JPG
- Countertop – Ceramic or Porcelain Tile
 - <http://www.showroom411.com/Media/Category/tilecounter.jpg>
- Bathroom Wall – Ceramic or Porcelain Tile
 - <http://www.renovation-headquarters.com/images2/bathroom%20porcelain%20tile.jpg>
- Toilet – Low Flow
 - http://www.foxnews.com/images/326620/0_61_toilet.jpg

+ 2 Build Out:

- Floor – Green Carpet & Cork
 - http://www.blcflooring.com/Images/Best/Best_Carpet.jpg
- Cabinetry – Bamboo
 - <http://www.bamboohardwoods.com/mmBAMBOO/Images/cabinets.jpg>
- Countertop – Green Laminate
 - <http://images.doityourself.com/stry/laminatcomeback2.jpg>
- Bathroom Wall – Glass Tile
 - <http://images.myknobs.com/dynamic/review-4382-1-zoom.jpg>
- Toilet – Dual Flush
 - http://green.apartmenttherapy.com/images/uploads/9_21_2007-sterlingrockton.jpg

+ 3 Build Out:

- Floor – Green Carpet & Bamboo
 - http://www.jetsongreen.com/images/2007/12/09/next_in_line.jpg
- Cabinetry – Wheat Grass
 - <http://www.kitchendesignsremodeling.com/green-large/wheatgrass-cabinetry.html>
- Countertop – FSCC Butcher Block Wood
 - <http://www.strawsticksandbricks.com/images/categories/DSCN1167.JPG>
- Bathroom Wall – Terrazzo or Stone
 - <http://www.berlinwallpaper.com/dcfix/images/Terrazzo.jpg> (couldn't find wall pic)
- Toilet – Composting
 - <http://greatgreengadgets.com/gadgets/wp-content/uploads/2007/04/composttoilet.jpg>

All Build Outs will include Green Paints and Stains, Compact Fluorescent Light bulbs, Low Flow showerheads and sinks, and green ceiling panels.

Appendix F: Interviewees and contact information

Matt Arnar
Solar Flair
1-800-445-8030

Bruce Gallagher
Solar Design Associates
1-978-456-6855

Peter Hudde
Conservation Services Group
1-508-579-2375

William Lee
William T. Lee Real Estate
1-508-798-1801

Jared Markham
Weston Solutions
1-860-368-3204

Martin Orio
Water Energy distributor, Inc.
1-508-904-8122

Matt Root
Conservation Services Group
1-508-328-8079

Other Contact Information (given by interviewees)

Bob Perspvhini
Richard D. Kimball Company
1-875-221-5901

Lynn Grinn & Shoples
1-413-732-4336

Seth Crocker
Crocker Building
1-413-737-7803

Jeff Lynch
Enterprise Equipment
1-781-331-0990

Barbara Heller
City Official

Weston Solutions (WPI east hall)

Appendix G: Green Child Care Centers

Green Child Care Centers

A green child care center is one that is environmentally friendly. They take measures to ensure that the environment provides the best in health for children, offer locally-grown or organic food, and celebrate multiculturalism. Also children are taught to respect the earth and its precious resources.ⁱ

Eco-Healthy Child Care Checklist

The Oregon Environmental Council (OEC) provides an *Eco-Healthy [Child Care Checklist](#)* which has 25 environmental-health criteria for daycare centers. Of those 25 criteria, daycare centers must meet at least 20 of 25 items. 2 of the 25 items are mandatory: The use of nontoxic techniques to control pests and no smoking anywhere on the premises or in sight of children.

The Eco-Healthy Child Care Checklist can be accessed from

<http://www.oeconline.org/resources/publications/kitsandtipsarchive/2007EHCCChecklist>

So far this program that was created by the Oregon Environmental Council is endorsed by more than 230 daycare centers in the United States. The OEC's program acts as the basis for the current movement of daycare centers from conventional, to a more environmentally friendly basis. These daycare centers traditionally do cost more than typically daycare center due to the added cost of sustainable construction and building materials.ⁱⁱ However, as sustainable building becomes more common, the cost of such buildings is greatly decreasing which will also bring down the added cost of green daycare centers.ⁱⁱⁱ

Nearby:

Tolland Green Day Care Center
45 Tolland Grn
Tolland, Ct 06084
(860) 875-2795

Green Baby Home Daycare

Billerica, MA 01821

978-362-2188

<http://www.greenbabydaycare.com/>

Patti's Place Family Child Care

Reading, MA 01867

781-942-7957

The Kathy Herward Child Care Center

Andover, MA 01810

978-474-5451

The LEGO Creative Childcare Center

Enfield, CT 06082

860-763-3407

Plowshares Child Program

360 Lowell Ave

Newton, MA 02460

(617) 527-3755

<http://www.plowshareschildcare.org/>

ⁱ http://daycare.suite101.com/article.cfm/environmentally_friendly_child_care_centers

ⁱⁱ http://seattletimes.nwsources.com/html/living/2004417688_webgreendaycare16.html

ⁱⁱⁱ <http://www.whitehutchinson.com/children/greenchildcare.shtml>