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GreenScreen: Software to Improve Campus Water and Energy Use

Andrew T. Silva
University of Connecticut - Storrs, andrew.timothy.silva@gmail.com

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GreenScreen: Software to Improve Campus Water and Energy Use

Andrew Silva

Water and energy are intrinsically linked together. Energy is required to produce clean water and water is used heavily to generate energy. These two resources are constantly held in check, as they are vital to the sustained operation of towns, cities, and campuses. At UConn, the consumption of water and energy is reduced by an efficient power plant and a brand new water reclamation facility. To reach beyond these accolades, it is essential that a deeper understanding of campus water usage is developed. Linking this knowledge with information about the energy consumption of UConn facilities will allow for the recommendation of efficiency improvements. Software was developed that demonstrates these trends and provides a tool for smarter campus and community growth.

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1.0 Introduction and background

1.1 Motivation

As the world's population increases, global water and energy demand are also on the rise.[1,2] Over the past decade, world per capita electricity consumption – a subset of total energy demand – has been steadily increasing, as shown in **Figure 1**. The United States is not an exception to these trends. The Department of Energy projects that between 2011 and 2040, total U.S. primary energy consumption will continue to increase at a rate of 0.3 percent per year.[3]

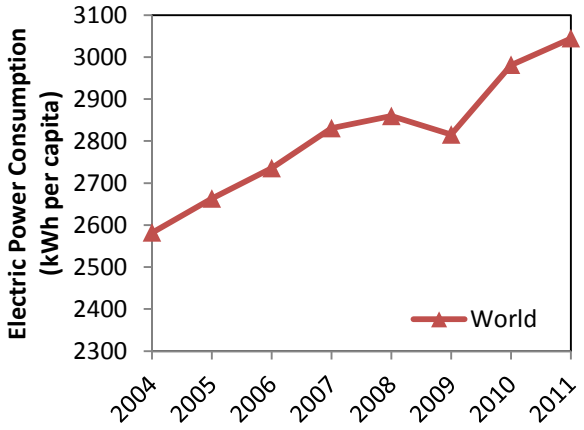


Figure 1 - World Per Capita Electricity Consumption.[4]

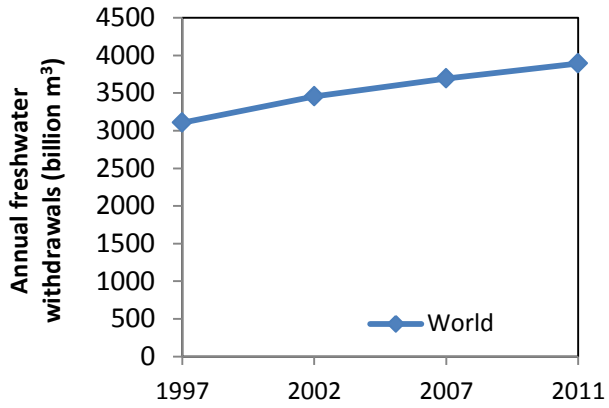


Figure 2 - World Freshwater Withdrawals.[5]

Global water usage data, while less frequently reported than electricity usage, also indicates a rise in demand over time, as shown in **Figure 2**. There is no panacea to meet the challenge of increasing water and energy demand; improvements must be made on multiple fronts. Efficiency improvements over a wide variety of technology, ranging from home appliances to commercial building components, will help to address rising energy demand.[3] Strides in electricity generation, like the use of cogeneration-style power plants, will work to reduce the consumption of natural resources.[6] And as society continues to accept new uses for reclaimed water, freshwater withdrawal rates will decline. While new technologies and new efficiency improvements for appliances are all necessary, they do not address existing

infrastructure that cannot be easily or cheaply replaced. Another necessary approach to reducing water and energy consumption is the development of tools that promote smarter management of these resources. This is a critical step towards reducing inefficiencies in large scale systems like cities and industrial sites and can promote community awareness of their environmental impact.

1.2 University of Connecticut as a green campus

The University of Connecticut (UConn) has established a culture of environmental sustainability. The school's Office of Environmental Policy has been particularly active in the past years, gaining recognition from a number of environmental advocacy organizations. UConn has shown a commitment to reducing its environmental impact, especially through the sustainable operation of the campus's newest buildings. Laurel Hall, a 68,000 square foot classroom building, recently achieved LEED Gold Certification. A few other campus buildings have received LEED Silver Certification and Oak Hall is still being considered for LEED Gold certification.[7]

The university has also been recognized for its overall campus sustainability efforts by the Sierra Club. In 2013, UConn was awarded the top ranking on the organization's list of "Cool Schools." Evaluation criteria for this ranking included reduction in energy and water consumption, the number of faculty involved in sustainability research, and campus sustainability awareness, among many other factors.[8]

Beyond its sustainability programs, UConn has taken the initiative to invest in state-of-the-art facilities aimed at improving the efficiency of operating the campus, including a $20 million Water Reclamation Facility (WRF).[9] This new plant uses microfiltration and ultraviolet disinfection to further purify treated wastewater for use in the campus's Central Utility Plant (CUP).[10] The CUP, the campus power plant, uses more water than any other building or facility

at UConn, which it needs for cooling purposes and steam generation. The WRF was designed with the intention of using the reclaimed water in the CUP's cooling tower in lieu of the drinking water. Potable water would still be used in steam generation, however, because the non-potable water from the WRF contains salts and minerals that could build up in and damage the steam lines.

1.3 Water and Energy Sources and Uses at UConn

The overall infrastructure of the University of Connecticut Storrs campus is immense and complex. The flow of water and energy, however, can be simplified by the block diagram as shown in **Figure 3**. The cycle begins with the water that is drawn from the Willimantic River and Fenton River wellfields.[11] The potable water from these wells is responsible for supplying campus buildings, the Central Utility Plant, and most recently, the Water Reclamation Facility. The Central Utility Plant, which generates steam from potable water, supplies electricity to campus buildings, the Water Pollution Control Facility, and the Water Reclamation Facility. The CUP is the largest single user of water, while the WPCF is the largest single user of electricity on campus – a demonstration of the interconnectedness of water and energy resources. Despite its large water usage, the CUP uses cogeneration, which is much more efficient than conventional power plants; impressive efficiencies of 60 to 80 percent can be achieved compared to 30 to 40 percent for a conventional power plant.[6]

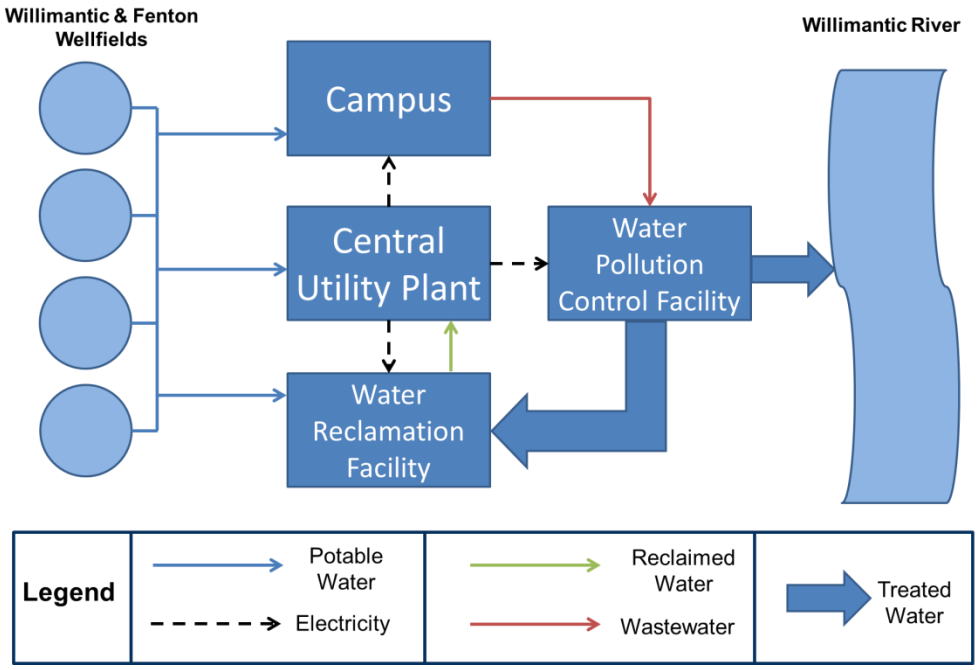


Figure 3 - Block diagram of University of Connecticut Storrs Campus operations.

Wastewater generated from campus buildings and sewers is sent to the WPCF for treatment. The wastewater is first sent through a solids screening stage and grit chamber. The removed solids are transported to a landfill and the liquids move onto two large oxidation ditches. During this step, activated sludge is used to treat the wastewater. The mixture of treated water and activated sludge is then sent to two clarifier basins. In this step, biological solids settle to the bottom of the basin and are recycled back to the oxidation ditches. Water from the top of the clarifiers is then sent to a disinfection step. Sodium hypochlorite is introduced to the water in chlorine contact tanks, until it is properly disinfected. Then, sodium bisulfite is added to prepare the water for discharge into the Willimantic River.[12]

A portion of the treated water is then directed to the Water Reclaim Facility. This plant further purifies the treated water by microfiltration and ultraviolet disinfection.[10] The non-potable water produced from this process enters a 1 million gallon storage tank, where it is then piped to the Central Utility Plant for use as cooling water.

University buildings receive electricity, steam, and chilled water from the Central Utility Plant. A series of pumping stations supply potable water to the buildings from one of two large storage tanks.[12] These buildings and the sewers on campus provide wastewater to the Water Pollution Control Facility.

1.4 Research Objectives

While UConn has shown a tremendous commitment to environmental sustainability, improvements can still be made. For example, issues involving salt buildup in the closed-loop water reclaim system are currently preventing the facility from providing the full intended capacity of water to the power plant. A potable water line has been installed at the WRF to dilute the reclaimed water, as a temporary solution to this problem. Since the single purpose of this facility was to reduce the amount of potable water used in the overall system, a more permanent solution will need to be implemented in the future. Furthermore, as buildings age, updating the heating and cooling systems in these buildings will be required in order to reduce operating costs. And as campus infrastructure deteriorates, it will be necessary to renovate pipelines and monitor for inefficiencies in overall campus operation.

A single solution does not exist that addresses each of the problems that can occur in such a large scale system, like a university campus. Solutions that improve water and energy use at UConn cannot be developed without specific and sufficient information about campus operation. The goal of this project was to modernize the way that Operations personnel, and the general public, understand and access information about campus water and energy use. A software tool was created that gathers all available water, electricity, steam, and chilled water usage data into one highly visual interface.

2.0 Materials and Methods

2.1 Process Information System

The University of Connecticut uses a real-time data management suite from OSIsoft® called Process Information (PI) System.[13] This software is used widely by other universities and private companies; essentially any entity that collects and analyzes a large amount of process data in order to maintain their operations. The PI System allows real-time data to be collected from a number of different sources with a variety of interfaces, even if the sources come from different vendors and do not output data in the same format. It is a not a process control system, though the data can be collected and analyzed by PI, and operating conditions can be adjusted accordingly.

At UConn, PI is used to catalogue a host of information about campus operations. Data from the facilities that comprise the main components of campus infrastructure (**Figure 3**) is collected and stored on a PI Server. Power output data is available from the Central Utility Plant, water treatment rates are available from the Water Pollution Control Facility, and consumption data is available for campus buildings, among other values.

The data collected on the PI Server is accessible through a number of different user interfaces. Files called "ProcessBooks" can be created that display current trends for specifically chosen data sources. Process flow diagrams can also be created within these pages in order to display current process information on a visual interface. An example of a ProcessBook is shown in **Figure 4**.

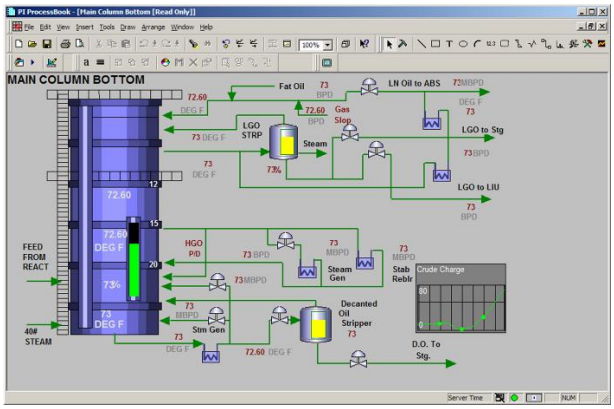


Figure 4 - ProcessBook for data visualization and process management.[13]

Data that the PI System records is accessible through a unique label called a "PI Tag." Each meter or piece of equipment that has been integrated into the UConn PI server is represented by one of these tags. While PI ProcessBooks can be custom made to display data from any of these tags, these user interfaces are only accessible to facilities personnel. This information is not readily available to the campus community, who could develop a stronger understanding of university infrastructure and campus resource consumption if this data were made available. GreenScreen is meant to tap into the UConn PI server and merge the functionality of a ProcessBook with the interactivity of a Google Map. The final product will provide a high-level view of campus operation that anyone who is familiar with Google Maps can utilize.

2.2 GreenScreen Web Application

GreenScreen was implemented by embedding HTML code within an existing webpage owned by UConn Energy Services. This website (energyservices.uconn.edu, Username: FAS\PI, Password: Uconn2011) is a Microsoft SharePoint site that contains a dashboard for viewing information relating to campus operations. GreenScreen was designed to expand the capabilities of this dashboard. One of the main components of the current site is a page that displays a list of

electricity and domestic water metering data for each campus building. These lists only display the total amount of water or total energy consumed over the current day, in addition to the totals from the two previous days. The existing dashboard and metering lists are shown in **Figure 5** and **Figure 6**. Compared to the existing dashboard, GreenScreen displays the live metering data in a more visual interface and has the added capability of viewing historical data.

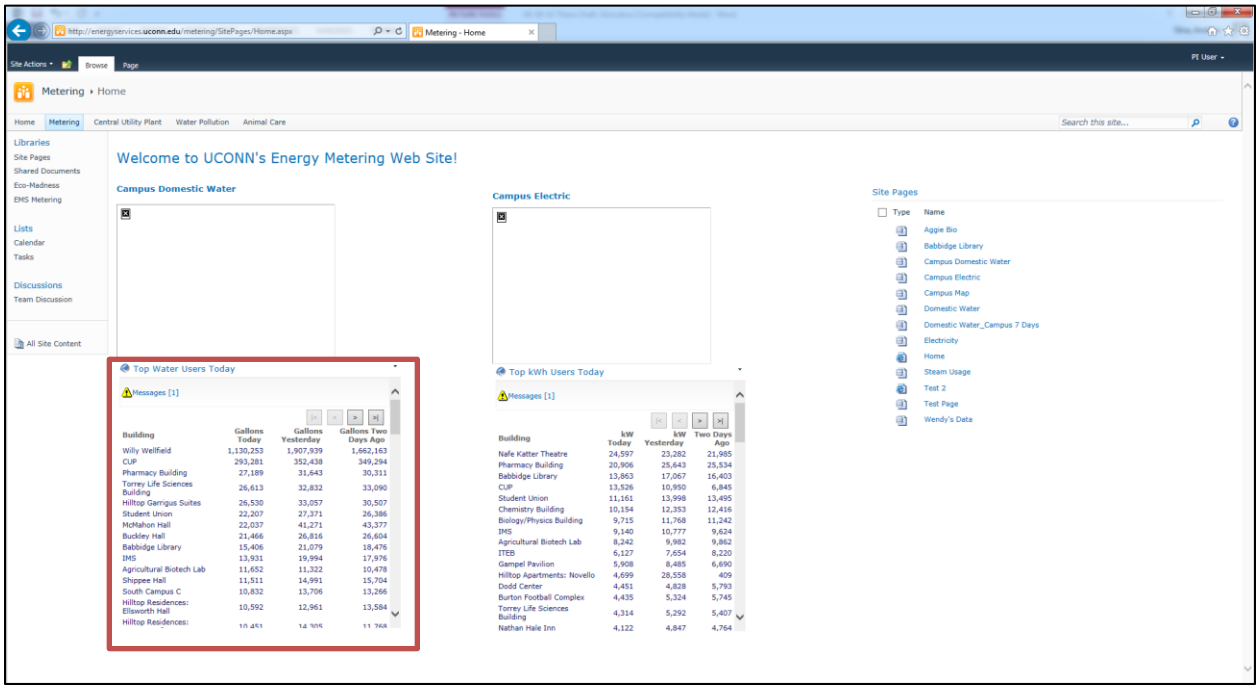
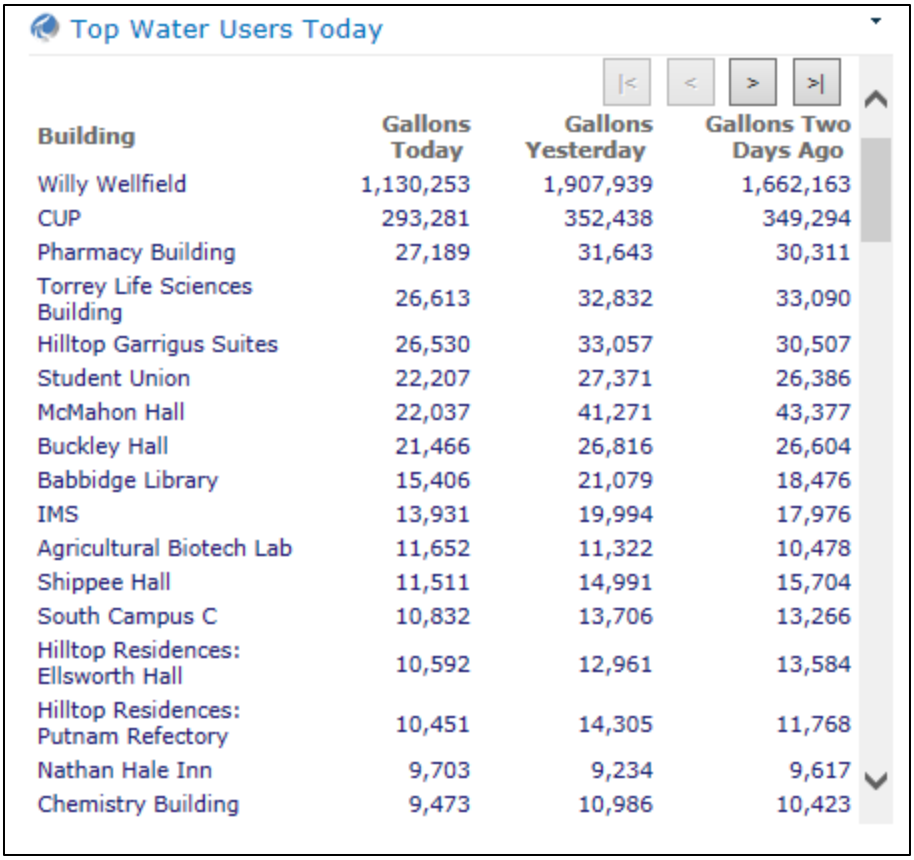


Figure 5 - Current UConn Energy Services Web Dashboard.



Top Water Users Today

|< < > >|

Building	Gallons Today	Gallons Yesterday	Gallons Two Days Ago
Willy Wellfield	1,130,253	1,907,939	1,662,163
CUP	293,281	352,438	349,294
Pharmacy Building	27,189	31,643	30,311
Torrey Life Sciences Building	26,613	32,832	33,090
Hilltop Garrigus Suites	26,530	33,057	30,507
Student Union	22,207	27,371	26,386
McMahon Hall	22,037	41,271	43,377
Buckley Hall	21,466	26,816	26,604
Babbidge Library	15,406	21,079	18,476
IMS	13,931	19,994	17,976
Agricultural Biotech Lab	11,652	11,322	10,478
Shippee Hall	11,511	14,991	15,704
South Campus C	10,832	13,706	13,266
Hilltop Residences: Ellsworth Hall	10,592	12,961	13,584
Hilltop Residences: Putnam Refectory	10,451	14,305	11,768
Nathan Hale Inn	9,703	9,234	9,617
Chemistry Building	9,473	10,986	10,423

Figure 6 - Current Energy Services Dashboard Metering Data.

GreenScreen was designed in HTML and integrates the Google Maps API through the use of Javascript programming. The web application accesses the PI server, catalogues real-time data in a Microsoft Excel spreadsheet, and then reads and displays the information on the client's browser. This process is shown in **Figure 7**. The application uses DataLink, an Excel Add-In designed by OSISoft®, which uses formulas to pull data from the PI Server. These formulas allow the user to specify a PI tag, a desired time range, and whether the values should be time-weighted averages, among other options.

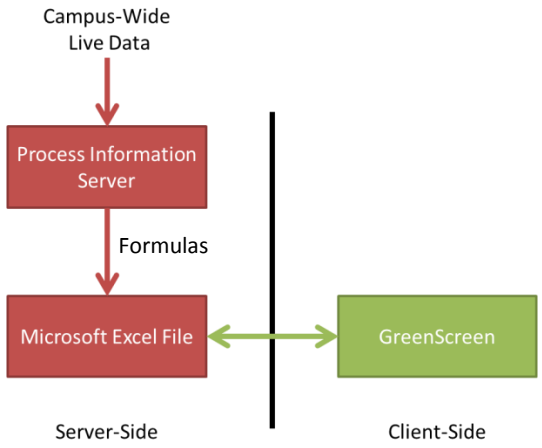


Figure 7 - Flow diagram showing how GreenScreen accesses the PI Server and displays data on a client-side web browser.

The spreadsheet that GreenScreen reads is a database of campus building information, complete with their geographic coordinates, associated PI tags, and building dimensions. The coordinates are used to place markers on buildings that have live meters. When a user clicks the marker associated with a building, the application recalculates, reads, and displays consumption data from the Excel spreadsheet. This process is used to display current usage data and a variety of historical charts for a particular building.

3.0 Demonstration and Discussion

3.1 GreenScreen Web Application

3.1.1 Current Usage Monitoring

When users load GreenScreen, the default view (**Figure 8**) shows a Google Map of the UConn campus, centered on the Central Utility Plant. Buildings that can display live resource monitoring are indicated by the water and energy icons. When a user clicks on an icon, a popup window will appear and display the current reading for that metric. The water icon will include consumption values for domestic water, steam, and chilled water. The energy icon will include current power usages for buildings, excluding the power plant. The energy icon on the CUP will display the current production rate of power.

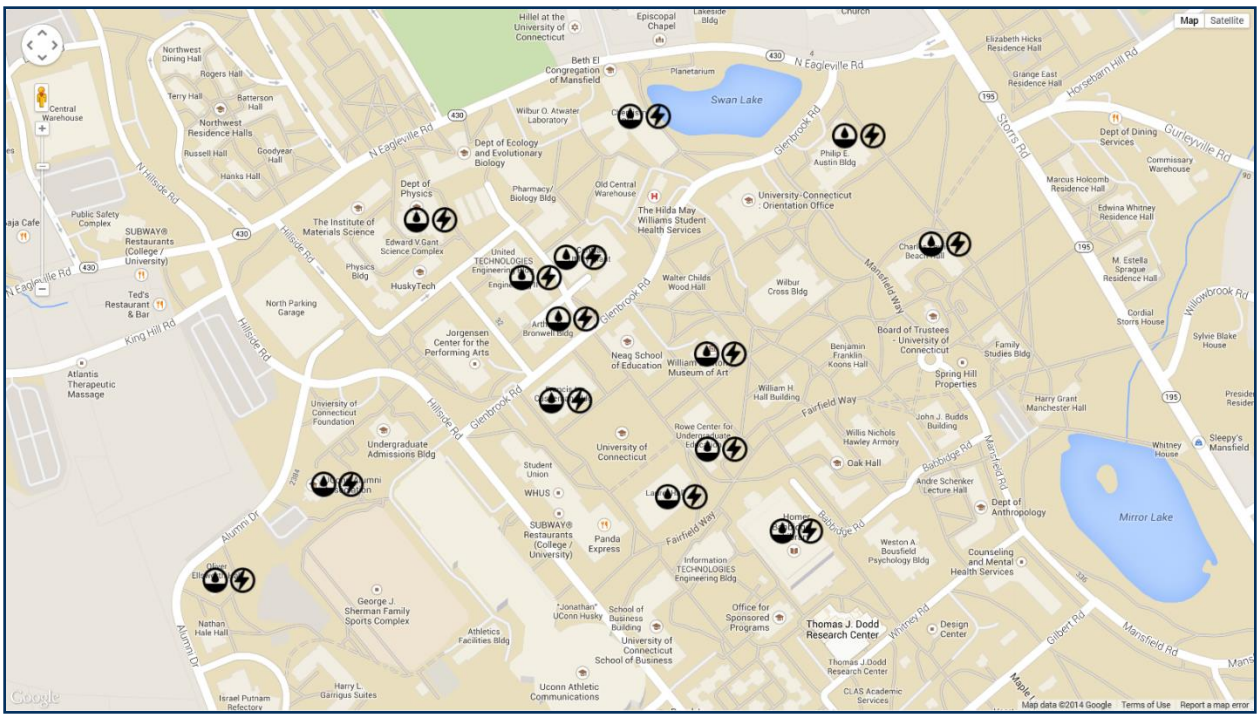


Figure 8 - Main view of GreenScreen, displaying the UConn campus with markers overlaid on buildings with live meters.

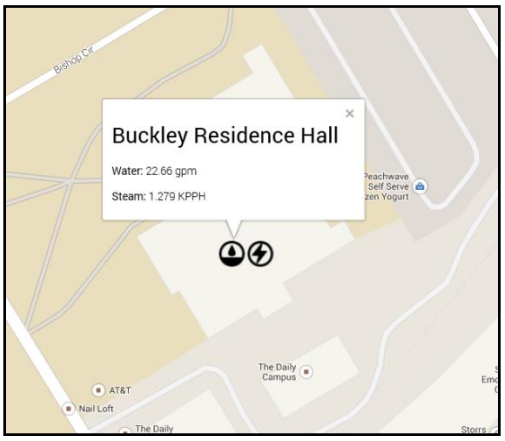


Figure 9 - Current Domestic Water and Steam Consumption for Buckley Residence Hall.

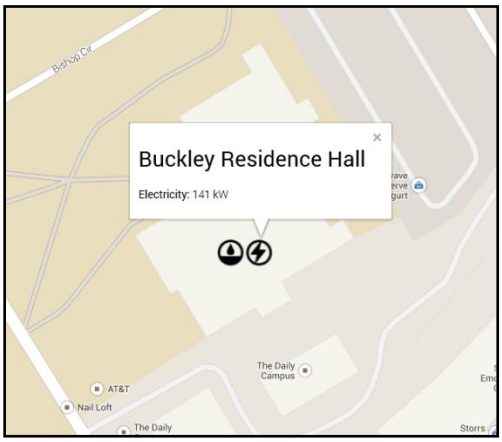


Figure 10 - Current Power Consumption for Buckley Residence Hall.

The current usage data feature of GreenScreen is mostly intended to raise awareness among the UConn community of the magnitude of resource consumption for which the campus is responsible. It is also intended for use by Facilities personnel to quickly check the status and value of a meter, replacing the need to search for that information in PI.

3.1.2 Historical Data View

When users click on a water or energy marker, a graph displaying historical data will appear on the side of the screen. The three buttons at the top of the chart allow the user to change the time range for the selected building to a 30-day view, a 6-month view, or a 1-year view. Individual data points can be highlighted by moving the cursor over the plotted line, as shown in **Figure 11**. The historical data view also gives the user the option of normalizing the usage data by the building's area; an important feature when using GreenScreen to compare the resource consumption of two building that have a similar function, but are not the same size.

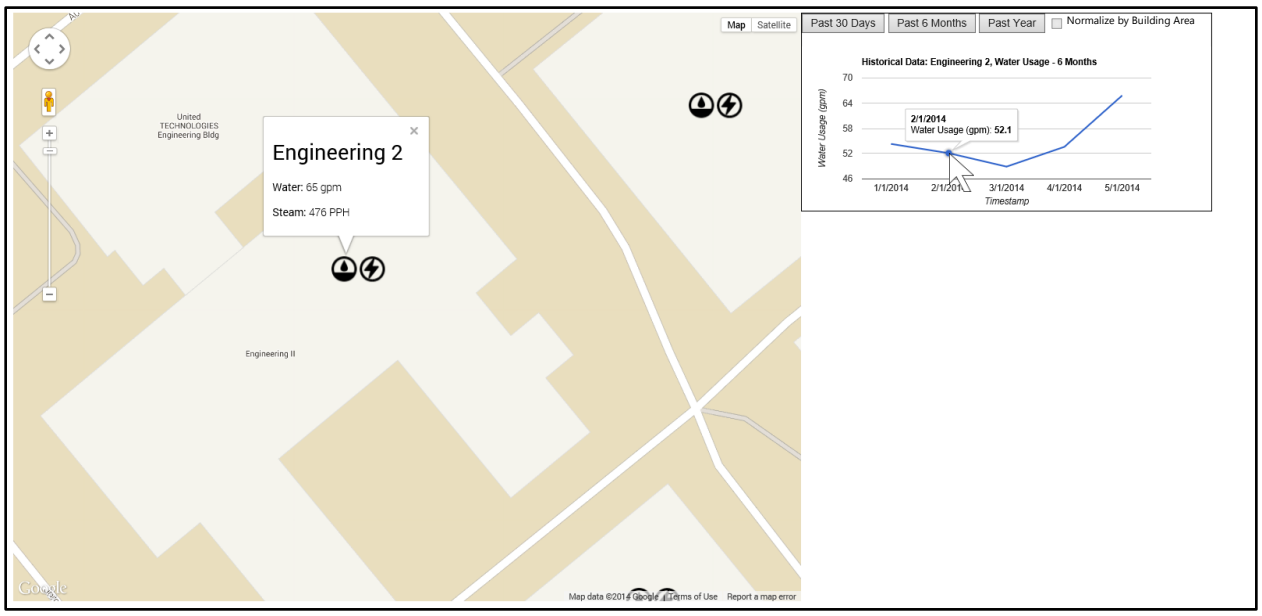


Figure 11 - Historical data view of GreenScreen, showing the 6 Month water usage average for the Engineering 2 Building.

3.2 UConn Building Resource Consumption Comparison

GreenScreen can be used to compare all types of buildings, but the most meaningful comparisons come from those that have similar functions. For example, on the UConn campus, both the United Technologies Engineering Building (UTEB) and Castleman are buildings that contain classrooms, offices, and laboratories. A GreenScreen comparison of the steam usage for

the two buildings, over the past month, is shown in **Figure 12**. From this chart, it is clear that on average, Castleman consumes more steam than UTEB. The 30-day average for Castleman is approximately 360 pounds per hour, while the average for UTEB is about 180 pounds per hour. The difference between these buildings could be caused by a number of factors, such as building size, building condition, or even behavioral elements. To narrow down the causes for discrepancies in building resource usage, GreenScreen allows the user to normalize any metering data by the area of that building. The normalized comparison of UTEB and Castleman is shown as **Figure 13**. The new plot shows that the steam consumption of the two buildings is much more similar than could be concluded from the original comparison. The 30-day area normalized average for UTEB and Castleman are 0.01284 PPH/ft^2 and 0.01234 PPH/ft^2, respectively.

Similar comparisons can be conducted in GreenScreen to determine the relative efficiencies of buildings with comparable functionalities. If similar buildings show significantly different normalized usages, then the heating or cooling equipment in that building should be examined and repaired. If the equipment in the building is functioning properly, then a behavioral study of the building's use should be conducted to try to link the efficiency data with the way the building is used.

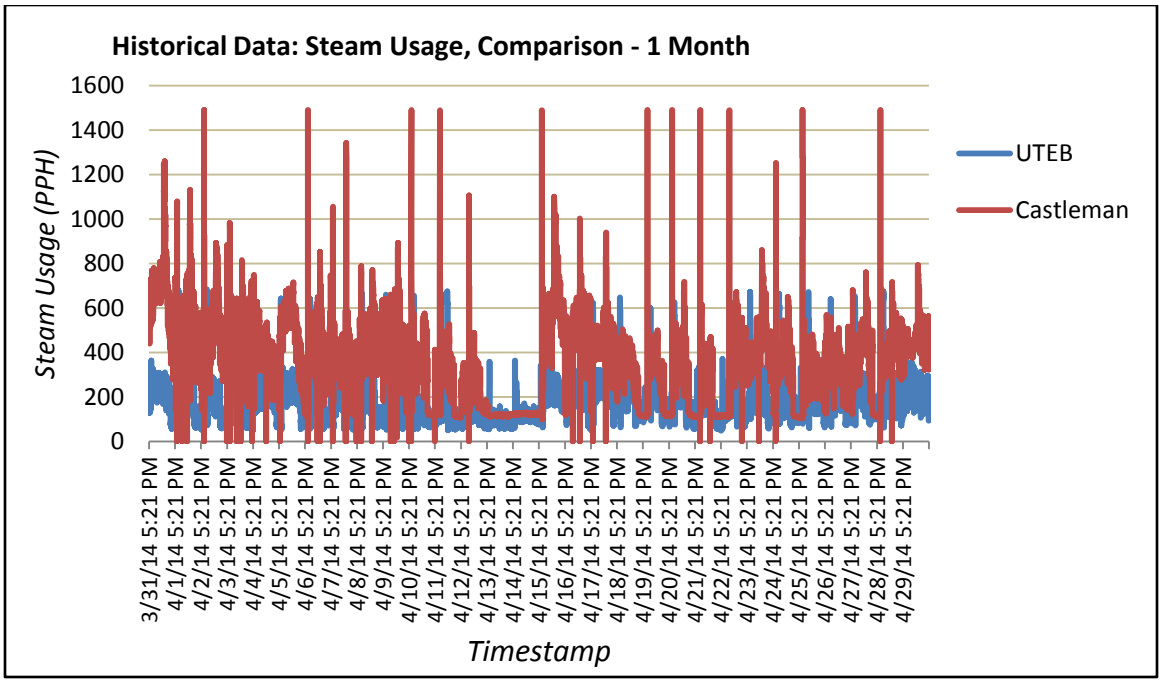


Figure 12 - Sample steam usage comparison of two similar functioning buildings: Engineering 2 and Castleman.

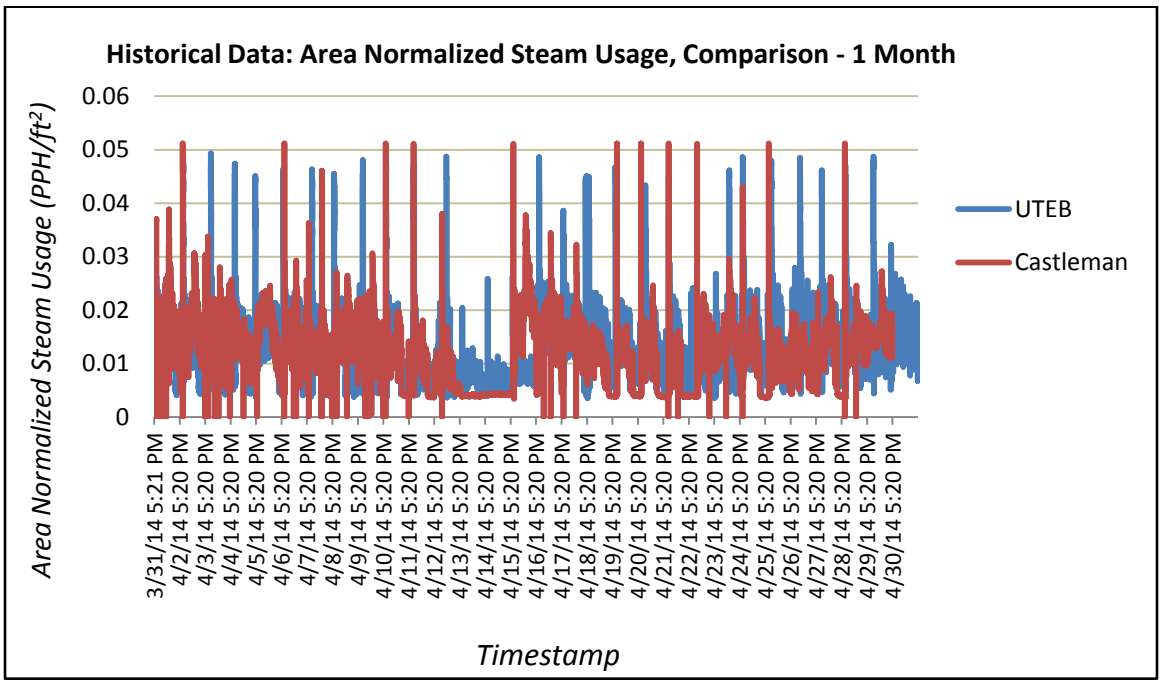


Figure 13 - Area normalized steam usage comparison of two similar functioning buildings: Engineering 2 and Castleman.

4.0 GreenScreen Business Plan

Executive Summary

Business Concept

SilverEnergy is a software company that is dedicated to the principles of efficiency and sustainability. This company, and the product it provides, is in direct response to the era of climate change and high energy prices. With this motivation in mind, SilverEnergy's mission is to create and implement software technologies to increase the water and energy efficiency of large scale systems. Currently, SilverEnergy is a non-registered/non-recognized company that is moving towards a startup phase in the next 1 to 3 years.

Product and Service

SilverEnergy will primarily offer a software product, called *GreenScreen*, which will have the following functions:

- Live Water and Energy Use Monitor
- Building Retuning Assistant
- Building Design and Integration Tool
- Teaching and Learning Tool (for undergraduate engineers)

External Analysis

The energy efficiency market is very broad, as it includes the development of any technology that lowers energy consumption. Some companies compete in this market by constructing efficient buildings, designing hybrid cars, or selling compact fluorescent light bulbs. There is another segment of this market that aims to increase the energy efficiency of existing buildings and groups of buildings; this is the portion of the market that SilverEnergy will enter to offer *GreenScreen*. The company's main target customers are college campuses as they consume large amounts of energy and some even have their own power plants. Unlike cities, the buildings on a college campus are owned by a single entity and can easily be integrated into a single energy and water use tool.

Internal Analysis

SilverEnergy will start as a very small company, but will eventually adopt an organizational structure with three main sectors: Technology, Operations, and Marketing/Sales. Each of these sectors will be directed by its own Vice President and various teams will be established under their direction. Specific hiring strategies, leadership techniques, and company culture are all defined further in the body of this plan. Each of these components will contribute to SilverEnergy's overall mission of providing sustainable energy solutions.

Marketing & Sales

The Marketing & Sales team will strategically target college campus Facilities workers in order to advertise *GreenScreen*. Relationships will be established with key contacts at various universities in order to bring about a proposal meeting. Once this meeting is established, SilverEnergy will highlight the potential savings that *GreenScreen* can bring to the campus. Once *GreenScreen* has been demonstrated at other campuses, these cost saving analyses will be more concrete.

Financial Requirements

To startup in an optimal situation, SilverEnergy will require an initial investment of approximately $500,000. These costs will cover software licenses, office space, computers, salaries for a small team, and a small marketing investment.

Risk Management

The biggest challenge that SilverEnergy has is raising the initial investment. One way of mitigating these costs is to use graduate level students in the R&D process. Further, to sustain operations after the startup phase, financial projections will be used to dictate hiring practices, to avoid operating outside of the company's means.

Business Concept

SilverEnergy is a software company that is dedicated to the principles of efficiency and sustainability. This company, and the product it provides, is in direct response to the era of climate change and high energy prices. With this motivation in mind, SilverEnergy's mission is to create and implement software technologies to increase the water and energy efficiency of large scale systems. SilverEnergy's technology is meant for college campuses, cities, and large industrial sites.

SilverEnergy will primarily offer a software product, called *GreenScreen*, which will integrate the following features:

- Live Water and Energy Use Monitor
    - Visualize the current water and energy uses of each building on an interactive map of a campus, city, or industrial site
    - Diagnose leakages in inaccessible water and steam lines
    - Identify where additional water and energy metering would be most beneficial
- Building Retuning Assistant
    - Process of making low/no-cost changes to ensure that a building's existing equipment is working at its maximum efficiency
    - GreenScreen will provide a step-by-step walkthrough of this process as well as a place to record and trend important building data
- Building Design and Integration Tool
    - Evaluate the impact of a new building on the current water and energy infrastructure

- Teaching and Learning Tool (for undergraduate engineers)
    - Simulate relatable examples of mass and energy balances
- "Lite" Version of All of the Above
    - Limited-features version of GreenScreen offered as a free online tool

Currently, SilverEnergy is a non-registered/non-recognized company that is moving towards a startup phase in the next 1 to 3 years. The business is currently owned by Andrew Silva and does not have any employees to date.

Partnerships have been developed with key staff and faculty members at the University of Connecticut. These include Richard Miller – Director of the Office of Environmental Policy, Jason Coite – Environmental Compliance Analyst, Donna Cyr – Director of the Office of Economic Development, and Timothy Tussing – University Operations. These partnerships will serve to accelerate the development and demonstration of SilverEnergy's *GreenScreen* on the University of Connecticut campus. Richard Miller and Jason Coite will specifically provide access to a vast amount of data that is necessary to complete a full study of the University's efficiency. Timothy Tussing will help connect the team to a number of important individuals within campus operations. Donna Cyr will provide assistance in Intellectual Property related items including a thorough patent search for similar existing products.

Product & Service

Development Status and Tasks

SilverEnergy will offer its services in the form of a computer program, called *GreenScreen*, which features the products mentioned in the Business Concept section. Currently, these specific functions are being developed. Also, a visual prototype has been created in order to convey the fundamental ideas of each feature to potential stakeholders and partners. The most immediate and tangible development goal of this phase of the business is to create the software and demonstrate its value to the University of Connecticut, Storrs Campus.

The following is a collection of tasks required to develop the services of *GreenScreen*. The task descriptions in the timeline correspond to a more detailed set of tasks listed below the timeline. The boldness of the shading in each box of the Gantt chart corresponds directly to the amount of priority of that task.

Timeline of Development

		Month														
Phase	**Task Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	1. Water and energy information collection															
	2. Building Retuning Assistant Mode															
	3. Google Maps API Integration															
	4. Live Water and Energy Monitoring Mode															
	5. Design and Integration Mode															
	6. Evaluate and improve UConn															
	7. Written report on UConn's campus efficiency															
2	1. Explore Patent Protection															
	2. Investors and startup funding															
	3. Licensing to sell/protect software															

Phase I

1. Gain access to existing University **water and energy information**/data and continuously collect it for analysis (only during school sessions)
2. Develop **Building Retuning Assistant Mode** of software for analysis of individual building efficiency and the low/no-cost solutions that can decrease water and energy use
3. Research and integrate the **Google Maps API** into the software in order to provide a visual representation of water/steam/electricity lines on a "zoom-able" campus map
4. Develop the **Live Water and Energy Monitoring Mode** of the software to bring the available live water and energy metering to a more interactive platform
5. Develop the **Design and Integration Mode** of the software for new buildings to determine the potential effects on the current water and energy infrastructure (i.e. can current water pipes, electrical wiring handle the extra load?)
6. Demonstrate *GreenScreen* by **evaluating and improving UConn**'s overall efficiency
7. Provide a **written report** to the UConn Office of Environmental Policy on efficiency recommendations/instructions

Phase II

1. Explore the possibility of **patents** on all software developments (for adequate protection, this must take place one year after successfully filing a provisional patent)
2. Search for **investors** to acquire **startup funding**
3. Acquire **licensing to sell software** and to service campuses, cities, and industrial sites

Challenges and Risks

One of the inherent challenges in implementing this type of business is the availability of data. For example, each university campus, city, and industrial site will have a different amount

of pipes and electrical wires that are monitored for their flow rates and transmission rates, respectively. At UConn, the pilot environment for this software, basic water and energy metering exists for most buildings on campus. One of the steps in developing this product will be determining where more monitoring exists and where additional monitoring should be added.

Another difficulty in creating this product to the specifications of this plan is integrating the Google Maps API. If carried out successfully, this would allow the program to incorporate an interactive Google Map that can be panned and zoomed while displaying all of the water and electricity grids. There is a technological challenge in programming this feature into the software, while also using a programming language that is conducive to the other features described in this plan.

Intellectual Property

As mentioned previously, a partnership with Donna Cyr from the Office of Economic Development will be established. Initially, the concept of *GreenScreen* will be presented to this department for the purposes of conducting an initial patent search to determine the uniqueness of this software and its potential for intellectual property protection.

External Analysis

Market Analysis

SilverEnergy and *GreenScreen* Technology fit directly into the Energy industry. The energy industry can be split into many different categories. For example, there are companies that provide fuels, such as gas and oil companies, while there are others that generate and provide electricity. These areas of the energy industry are only concerned with delivering energy sources or using those sources to generate power. The focus in these areas is to meet the energy demand of customers by providing enough fuel or electricity. There is a third market within the energy industry, the energy efficiency market, that focuses on providing products that lower the demand for fuel or electricity, without affecting a customer's natural routine or lifestyle.

The energy efficiency market is very broad, as it includes the development of any technology that lowers energy consumption. For example, some companies compete in this market by constructing efficient buildings, designing hybrid cars, or selling compact fluorescent light bulbs. There is another segment of this market that aims to increase the energy efficiency of existing buildings and groups of buildings; this is the portion of the market that SilverEnergy will enter in order to sell *GreenScreen*.

The entire energy efficiency market received about $300 billion in the U.S. during 2004.[14] The following table shows the different segments of this industry and their respective investments:

Table ES-1. Energy Efficiency Investments Summary

	Buildings	Industrial	Transportation	Utilities	Total
Total Energy Use (quads)	38.9 (39%)	33.6 (33%)	27.9 (28%)		100.4 (100%)
Total Efficiency-Related Investments ($billion)	178	75	33	15.7	300
Premium Investments ($billion)	24	11	5	2	43
Investment- Related Employment (000)	990	351	151	139	1,630
Energy Savings (quads)	.72	.66	.08	.19	1.7
Energy Savings ($billion)	12.2	5.6	1.1	0.5	19.5

* Note: Totals may not match due to rounding.

SilverEnergy is poised to enter under many of these categories and can benefit directly from the large amount of investments in each sector. For example, one of *GreenScreen*'s main features is the Building Retuning Assistant. This specific feature can provide energy savings to a customer by implementing low/no-cost solutions in order to enhance building efficiency. This one aspect of *GreenScreen* will fall within the building sector of the energy efficiency market.

It is interesting to note that the industrial sector only received 25% of efficiency investments, while consuming 33% of the nation's total energy use. Since one of SilverEnergy's primary target markets is industrial sites, this presents a unique opportunity to promote an increase in industrial efficiency investments. Similarly, the analysis of college campus infrastructure with *GreenScreen* represents a very large (and mostly untapped) source of business for SilverEnergy.

Target Customer

The following lists the target customers for SilverEnergy's *GreenScreen* Technology:

- Cities and towns
    - specifically larger sized towns that use enough water and energy to have their own water and power plants

- College campuses
    - specifically those large enough to have their own water and power plants
- Industrial sites
    - specifically those that have water and/or energy intensive processes that occur daily

The major commonality between these three target customers is that they all require a significant water and energy infrastructure. These resources can constitute a large part of these customer's operating budget (UConn spent $26 million in 2011 on energy alone) and many of these institutions lack basic water and energy management tools. This presents a unique opportunity for SilverEnergy to analyze a site's resource management, provide the infrastructure necessary for the use of *GreenScreen* (i.e. remote accessible water and energy meters), and sell a renewable license to the software.

Revenue

The revenue drivers for SilverEnergy will be the sale of the *GreenScreen* software, the consulting fee for site analyses required during the implementation of *GreenScreen*, and a monthly service charge to cover any troubleshooting costs. At this point, the actual dollar value of the software and services has only been estimated (and expanded upon in the Marketing & Sales section). The goal is to create a working prototype and use it to evaluate the efficiency of the University of Connecticut. Then, once the water and energy management recommendations have been made and the institution's cost savings have been estimated, the value of the software will be determined.

Fixed and variable costs

Fixed expenses for SilverEnergy will come in the form of employee salaries and benefits, licensing costs, developing software costs, patent costs, rent costs, and digital storage (DVDs) costs. Variable costs will include hourly wages for technicians that service any issues that customers have with the software. At this point in time, the amount offered in salaries has not been estimated. Once the potential revenue of the software has been determined, the salaries of employees and their equity in the company will be set forth.

Startup Costs

The only anticipated startup costs over the next year are the one-time fee of about $100 for filing a provisional patent and the approximately $120 fee for officially registering a new company in the State of Connecticut. Following this year, more costs will be incurred by hiring employees, purchasing developing software, and buying office space. These costs are communicated in the financial projections section.

Direct Competitors

Due to the large industry of energy efficiency, SilverEnergy will be required to compete with companies for a niche place in this market. There are many existing software packages that aim to increase the efficiency of a system. In fact, the U.S. Department of Energy developed its own software for building efficiency simulations, called *Energy Plus.*[15] This software requires a large number of complicated parameters and is very cumbersome to use without proper training. *GreenScreen* will be designed to process easy-to-measure quantities and provide a visual environment for intuitive operation.

Another company, Agentis Energy, provides energy efficiency solutions for businesses. They sell SmartMeters and provide analyses of utility usage at a customer's location. While Agentis offers in depth analyses of energy usage, they do not target college campuses as key customers. The outreach to universities could be the differentiating factor between SilverEnergy and companies that offer similar services exclusively to businesses.

Indirect Competitors

Companies that provide campuses or other locations with energy can act as indirect competitors. If these entities (i.e. the company that sells natural gas to UConn) lower their fuel prices, it may not be financially justifiable to purchase a product such as *GreenScreen*. On the other hand, if energy prices increase, an opportunity arises for SilverEnergy to pitch a cost saving solution to that customer.

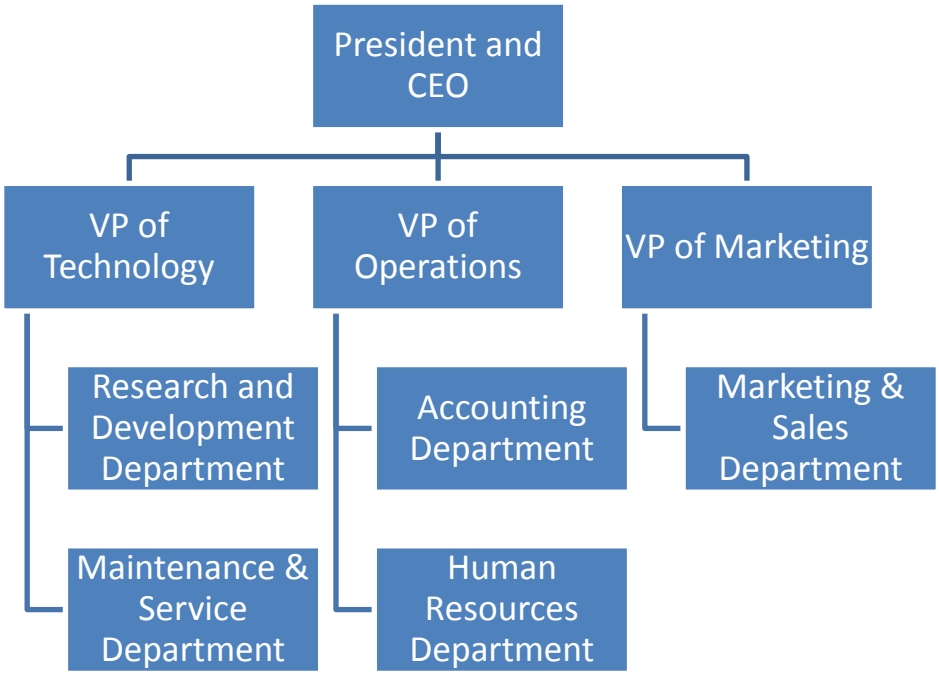
Community

Since *GreenScreen* targets college campuses as a large portion of its customers, SilverEnergy will commit to sponsoring student run philanthropies, providing guest lectures for undergraduates, and promoting environmental sustainability in the local area.

Internal Analysis

Organizational Structure

While SilverEnergy does not have any employees at this point in time, the following chart describes the type of hierarchy and team structure that will be used once partners and employees are established.



The President of SilverEnergy will set the vision and goals for three distinct Vice Presidents: VP of Technology, VP of Operations and Maintenance, and VP of Finance and Marketing. The VP of Technology will oversee the Research and Development (R&D) and Maintenance & Service departments, the most critical sectors of SilverEnergy. Since *GreenScreen* is still a developing software solution, a significant amount of resources will be given to the VP of Technology. For example, the majority of the company's budget will be allocated to the R&D team in order to hire a strong team of software engineers and purchase any resources the team may need (i.e. software, licenses, etc.). Further, once the product lines are

launched, there will be a shift in resources from R&D to Maintenance & Service in order to adequately service SilverEnergy's products. The Vice President of Operations will ensure that daily business operations are conducted smoothly both internally and externally. This will be accomplished by overseeing the Accounting Department (external business operations) and the Human Resources Department (internal operations). Finally, the VP of Marketing will be in charge of the company's Marketing and Sales Department. This individual and their team will be responsible for reaching college administrations, the company's target customer, in order to advertise and sell *GreenScreen*.

Management

Management Team

The management team of SilverEnergy will consist of managers for each of the areas of the company. There will be one manager each for R&D, Maintenance & Service, Accounting, Human Relations, and Marketing & Sales. These managers will oversee the everyday operations of each of these departments. They will also compile their department's budget and submit the proposal to the appropriate Vice President. The Vice Presidents will interact directly with the CEO and President, while the managers will interact directly with their respective Vice President. If needed, managers in larger departments will be allowed to appoint an Assistant Manager or subdivide their department into smaller parts to improve efficiency.

Board of Directors

The Board of Directors will be an elected body by the shareholders of SilverEnergy. The Board will not be established until partners, executives, and employees have been established. In other words, the Board will not serve to direct the startup of SilverEnergy, but will begin once

the company is established. The purpose for this is to eliminate the risk of recruiting Board members before the company's financial situation is solidified and not have the means to compensate the Board of Directors. The Board will be made up of a Chairman and eight other members. The Chairman must not be the CEO/President of SilverEnergy to avoid any conflict of interest in matters concerning the CEO/President's compensation. The Board will serve in many capacities, including but not limited to: approving overall budgets, determining compensation for executives, and managing company investments.

Board of Advisors

The Board of Advisors for SilverEnergy currently consists of three members: Jeffrey McCutcheon, Ph.D., Jeffrey Meunier, M.S., and Douglas Cooper, Ph.D. Each of these individuals brings a specific set of experiences to the advising of SilverEnergy and the development of *GreenScreen*. Dr. McCutcheon is an expert in water filtration technologies, specifically technologies that are sustainable, and brings knowledge of UConn's water treatment process to the business. Mr. Meunier works as a teaching faculty member at UConn for the Computer Science Department. Under his guidance, the software platform that *GreenScreen* will use will be selected and its capabilities will be determined. Finally, Dr. Cooper currently serves as Head of the Chemical and Biomolecular Engineering Department. Dr. Cooper has experience in starting his own business, specifically in the field of process control, and will be able to advise SilverEnergy on how to bring its unique product to market.

In addition to the individuals that have already agreed to serve on the SilverEnergy Board of Advisors, advisors with other areas of expertise will be sought in the near future. Advisors that specialize in finance, marketing, patents and licensing will be required to successfully start

SilverEnergy. These individuals will be searched for over the course of the next year. Compensation will not be provided to advisors as membership will be voluntary.

Skill Sets

Management

Different types of skillsets will be required of each of the various managers in SilverEnergy. These skillsets and their respective departments are summarized in the table below.

Department	Skill Set of Manager
Research & Development	• Ability to delegate tasks and track progress • Knowledge of technology (specifically software development, water technologies, and energy technologies) • Ability to create and maintain a department-scale budget • Ability to set and follow through with broad and specific research goals
Maintenance & Service	• Ability to delegate tasks and evaluate performance • Ability to manage logistics of maintenance schedules, (specifically prioritization) • Knowledge of troubleshooting methods • Exceptional knowledge of the software and hardware involved in *GreenScreen*
Accounting	• Public Accountant Certification (CPA) • Experience dealing with purchase orders and contracts
Human Relations	• Experience in hiring employees for technical and non-technical jobs • Knowledge of pertinent employment laws • Experience in maintaining a good working environment (specifically providing training in anti-harassment, dealing with any workplace conflicts, etc.)
Marketing & Sales	• Knowledge of the energy efficiency market • Strong networking skills (needed to make connections with University Administrations) • Experience selling to organizations (as opposed to selling to individual consumers)

Non-Management

The skillsets required for non-management employees will be dependent on their department. Employees working in the R&D department will undoubtedly require multiple years of work in a software related field. Applicants that have hands-on troubleshooting experience will be suitable to work in the Maintenance & Service department. The Human Relations and Marketing & Sales departments will require its employees to have strong people and organizational skills. Finally, applicants to the Accounting department will need to have a comparable level of financial experience to the position for which they are applying.

Culture

Sustainability, Responsibility, and Service are at the core of SilverEnergy's mission. Our employees will work each day to promote the development, sale, and maintenance of a software solution that increases efficiency. The whole purpose of advancing this technology is to promote sustainability. We also believe that our generation has a responsibility to decrease the amount of energy we consume (especially if non-renewable fossil fuels are involved) so that the next generation can enjoy a world with a never-ending supply of energy, free from the harmful effects of global climate change. Finally, all of our employees will be required to give back to the local community through service. These communities will know our company's name because of the impact we will have by sponsoring local fundraisers, providing tours to college students, and promoting environmental sustainability.

Niche

Currently, the biggest differentiating factor for SilverEnergy is its application to college campuses that are aiming to reduce their operating costs. There are many other companies that sell efficiency solutions for home or personal use, but *GreenScreen* is designed for larger-scale systems. SilverEnergy will also become known for its strong maintenance and service program.

Within the Maintenance & Service department will be a Customer Service center. Customers will be able to call or email a representative that will diagnose the customer's problem and delegate the service job to a technician. The customer will receive an estimate on the amount of time it will take to solve the issue and will be put in direct contact with the technician that is most qualified to address the issue. SilverEnergy's strong Customer Service program combined with its unique product and target customer will position the company to become a market leader in large scale efficiency solutions.

Human Resources

Recruitment and Selection

SilverEnergy recognizes that the strength of the company relies on the recruitment of top-notch, experienced employees. To build the R&D department during the early stages of SilverEnergy, HR will focus its recruitment on software engineers with at least 5 years job experience. Once the company is more established, the HR department will shift focus and recruit young talented software engineers straight from college. Starting with experienced engineers will allow *GreenScreen* to be developed faster. Shifting focus to young engineers later on will promote the generation of fresh ideas. The HR department will implement this strategy by posting Job Description advertisements in local newspapers, job search websites, and the company website. The recruitment of younger employees will be made possible by establishing a relationship with colleges and by attending their career fairs.

Selection of employees will be done in a three step process. The first step is a resume screening: the initial applicant pool is narrowed down based on the amount of experience required for the position (i.e. programming experience for an R&D software engineer). Second, applicants will be invited to an in-person interview. This interview will be comprised of

behavioral questions as well as questions to verify an applicant's level of qualification. Every interview for the same position will last the same amount of time, but may be different for other positions. The final step of the selection process will be a reference review. The HR employee will contact the references that the applicant provided and will use these conversations to verify the information given in the applicant's interview.

Training and Development

The manager of each department will be responsible for working with HR to create a training program for each type of employee in their department. All training programs will be on-the-job training. The manager of a department may delegate this responsibility to supervisors who will work directly with the new employee. To foster the development of all workers, scholarships will be awarded, through an application process, to employees that wish to enroll in outside training programs or classes. The application for these scholarships will be evaluated based on the added value an employee could bring to the company with their additional class or training.

Performance Appraisals and Feedback

Feedback on an employee's performance will be given frequently by their supervisor or manager. Additionally, SilverEnergy will use an annual review process to officially assess the performance of each of its employees. These evaluations will be completed by managers or supervisors that work directly with their employees. The results of this evaluation will impact the decision to offer raises to employees or in other cases, fire employees. Managers and supervisors will be advised to link each piece of feedback to the employee's job description so that any discrepancies may be cleared up.

Pay and Benefits

Based upon research of salaries in various occupations, the following is a rough estimate of the salaries of a few different types and levels of employees in SilverEnergy.

Type of Employee	Starting Salary
Entry-Level Software Engineer	~$60,000
Intermediate-Level Software Engineer	~$75,000
Senior-Level Software Engineer	~$90,000
Entry-Level Accountant	~$45,000
Senior Tax Accountant	~$75,000

Estimated salaries of employees[16]

All full time employees will receive benefits that include health insurance, a set number of vacation and sick days (to be increased with exceptional performance reviews), and retirement plan options. Part time employees will not be offered health insurance or retirement options and will be given a smaller number of paid sick/vacation days.

Employee Relations

All new hires will be required to take a workshop on preventing harassment in the workplace. These new employees must pass a test (created by HR) that will ensure that they understand SilverEnergy's zero tolerance policy for any type of harassment. All employees will be required to retake the test annually. Employees will be offered the opportunity to retake the workshop at any time and will be encouraged to report any act of harassment to HR immediately.

Research and Development (R&D)

As is evident throughout the entirety of this business plan, R&D will be crucial for SilverEnergy, especially in its early stages. The development of each component of

GreenScreen will be the first barrier in creating revenue for SilverEnergy. Once this is overcome, R&D will still remain a keystone to this organization. Following the launching of *GreenScreen*, research will be done to evaluate the techniques and equipment used by small-scale or home use energy efficiency system companies to see if these methods can be scaled up and add more functionality to *GreenScreen*.

Production

It is the goal of SilverEnergy to promote sustainability and efficiency through its products as well as with its employees. The company's main resource is the time and effort of its employees. The efficiency of the company will rely on the output of quality technology from the R&D department and strategic service from the Maintenance department. By investing in highly trained software engineers for R&D and well-trained technicians for Maintenance, SilverEnergy will increase production of new technologies and build strong relationships with existing customers.

Leadership Technique

SilverEnergy will employ a democratic leadership technique in some areas of the business while using an autocratic technique in other areas. The relationship between the CEO/President and all Vice Presidents will be very collaborative. This group of individuals will need to bring all aspects of the business (Technology, Operations, and Marketing/Sales) together in order to effectively allocate the company's resources. The CEO/President will seldom make decisions alone, but will seek the advice of each of the acting Vice Presidents to assess the impact of the decision on each division of the company.

The opposite leadership technique will be used within each department. The manager of each department (R&D, Maintenance & Service, Human Relations, Accounting, and Marketing

& Sales) will use an autocratic leadership style in order to ensure that progress is made every day. For example, in the Maintenance department, it is essential that the technicians perform the specific duties assigned to them. There is less of a need for collaboration in these areas of the business and more of a need for consistency and performance.

Marketing & Sales

Overall Marketing Strategy

As stated throughout this plan, SilverEnergy will work to provide to a very unique sector of the energy industry: college campus efficiency. There are many other companies that provide to the home efficiency sector of this market, but their products are only useful for these smaller scale applications. SilverEnergy will offer *GreenScreen* as an analysis tool that can offer tremendous savings to universities by reducing their operating costs. The Marketing & Sales team will employ a unique strategy in order to reach our target customer. The sale of our product will depend on building relationships with university officials that deal with campus operations. These relationships will be initiated by making calls and sending emails to the Facilities offices (or other equivalent department) and offering a free estimate of energy savings by using *GreenScreen*.

Price

The following tables break down the various software and service packages of *GreenScreen*:

Software Options (select up to four tools)
Live Water and Energy Monitoring $5,000/license/year Variable installation costs*
Building Retuning Assistant $20,000/license/year
Building Design and Integration Tool $10,000/license/year
Teaching and Learning Tool $1,000/license/year

*Installation costs are dependent on the number of meters to be installed and the difficulty of working with existing infrastructure

Service Options (select one)
Basic: Periodic checkups, limited warranty on all installed parts/meters $500/month Variable service costs
Extended: Periodic checkups, limited warranty on all installed parts/meters, three free service visits per month $1,000/month Variable service costs (minus three free service visits)
Full: Periodic checkups, full warranty on all installed parts/meters, unlimited free service visits, same-day service $2,000/month

The Marketing & Sales team will work to put together these packages to provide a range of prices. For example, the most basic package will only offer one mode of the software whereas the full package will provide all modes. The customer will also have the option of selecting their Service package. The base package will include a warranty on installed parts as well as periodic checkups, to verify the accuracy of any installed meters or other equipment (frequency will depend on the type of equipment installed at that particular site). The full service package will include a guarantee that maintenance technicians will arrive on the same day that a customer reports an issue. The pricing of these packages is value-based and reflects only a fraction of the savings that are attainable through the use of *GreenScreen*.

Promotion

Advertising

SilverEnergy understands that it must target the individuals who are responsible for managing campus resources. With this in mind, the company will develop presentations and pamphlets that explain SilverEnergy's products and outline the potential cost savings. Then, the

Marketing & Sales teams will reach out to key employees at college campuses to schedule meetings to give the proposal presentation. The development of these pamphlets and presentations will be the first task of the Marketing & Sales team when SilverEnergy is established.

Public Relations

SilverEnergy plans to maintain a positive public image by encouraging its customers (i.e. universities) to use press releases to announce the impact that *GreenScreen* has on their campus. Further, SilverEnergy's community involvement will also result in a positive public image. Specifically, the company will sponsor local philanthropies and participate in other service projects.

Distribution

SilverEnergy will be prepared to sell *GreenScreen* directly to its customers, with one exception. The metering equipment that is required to interface with the software will be provided by a third party customer. Local vendors will be used to acquire this type of equipment and will vary based on the location of the customer. SilverEnergy plans on opening up a single location in the Hartford area that can service up to six critical potential customers: the University of Connecticut, Southern Connecticut State University, Central Connecticut State University, Western Connecticut State University, Eastern Connecticut State University, and the University of New Haven. Other campuses, like Yale University and the University of Hartford are so integrated into the city infrastructure that they are not considered potential customers at this point in time. As SilverEnergy expands and reaches out to more potential customers, more facilities will be acquired. Centralizing SilverEnergy's facilities around these customers will make the distribution of the software and the servicing of the existing products seamless.

5.0 Recommendations

5.1 Future development of GreenScreen

The functionality of GreenScreen can always be expanded as more information becomes integrated into the program. The level of detail of the application was designed to be simple enough to be used by the average campus community member, yet functional enough to be used by Facilities personnel. One potential area of improvement is increasing the cross-compatibility of GreenScreen to browsers other than Internet Explorer. IE is the only browser that supports the interactions between the GreenScreen program and Microsoft Excel. Further, to increase the usefulness of GreenScreen to Facilities personnel, automated alerts could be triggered by sudden fluctuations in a metered value. A set of criteria would need to be developed for each type of meter to characterize an abnormal spike. With this type of feature, GreenScreen would expand its functionality from just a monitoring and planning tool, to a diagnostic tool.

5.2 Future use of GreenScreen

The software in its current state is a practical tool for monitoring water and energy use and comparing the relative efficiencies of buildings on the UConn campus. It is recommended that GreenScreen be used to facilitate smart growth and planning practices. As more buildings are constructed and infrastructure is extended, GreenScreen can estimate the projected resource demand of proposed facilities through the analysis of similar existing buildings. Conducting this type of assessment early-on can determine the extent to which new infrastructure is necessary. For instance, if the projected heating demand for a new building significantly exceeds the capacity of existing steam lines, then the facility might plan to use electric heating to avoid high capital costs.

6.0 References

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7.0 Appendix

7.1 Nomenclature

API – Application Programming Interface

CUP – Central Utility Plant

HTML – HyperText Markup Language

PI – Process Information

WPCF – Water Pollution Control Facility

WRF – Water Reclamation Facility

7.2 GreenScreen Code

```
<!DOCTYPE html>
	<head>
	<meta name="viewport" content="initial-scale=1.0, user-scalable=no">
	<meta charset="utf-8">
	<title>UCONN GreenScreen</title>
	<style>
		body, html {
				height: 98%;
				width: 98%;
				padding: 0px;
			}

		#map_canvas {
			height: 100%;
			padding: 0px;
			margin-right: 100 px;
			position: relative;
		}

		#chart_div{
				float: right;
				position: relative;
				background-color: #ffffff;
		}

		#ChartPanel {
			position: relative;
			float: right;
			background-color: #ffffff;
			height: 100 px;
			width: 500 px;
			border: 1px solid #000000;
			}
```

```
	</style>
	<script src="http://maps.googleapis.com/maps/api/js?v=3.exp&sensor=false"></script>
	<script type="text/javascript" src="https://www.google.com/jsapi"></script>

	<script>
		//Universal Variables
		var map;
		var buildingData = [];
		var excel;
		var book;
		var sheet;
		var sheet2;
		var excelData = [];
		var selectedBuildingTitle;
		var chartTitle;
		var timeRange;
		var placeHolders = false;
		var ExcelIsOpen = false;

		google.maps.visualRefresh = true;

		function initialize() {
			var map_canvas = document.getElementById('map_canvas');
			var map_options = {
				center: new google.maps.LatLng(41.809492, -72.254484),
				zoom: 20,
				mapTypeId: google.maps.MapTypeId.ROADMAP
			}

			map = new google.maps.Map(map_canvas, map_options);

		getBuildingData();
		setMarkers(map, buildingData);
		getChartData(30);
		}

	//Open and read Excel file, build structure w/ pi tag, building name, data, and data
	function getBuildingData(){
		buildingData.length = 0;

		if (ExcelIsOpen == false) {
			ExcelIsOpen = true;
			excel = new ActiveXObject("Excel.Application");
			excel.Visible = false;
			book = excel.Workbooks.Open("C:\\Users\\Andrew\\Documents\\My
Dropbox\\UScholar Project\\Programming\\PIGreenScreenData.xls");
			//book = excel.Workbooks.Open("I:\\PIGreenScreenData.xlsx"); //RWF Version
			//book = excel.Workbooks.Open("http://greenscreen.eu.pn/GreenScreenData.xls");
//Website Version
			sheet = excel.Worksheets("Sheet1");
		}
		else {
			sheet.Calculate();
```

```
        }

        var rowCount = sheet.UsedRange.Rows.Count;

        var row = 0;
        for (var row = 2; row <= rowCount; row++){
                //Read Excel File Data With Headers
                //var buildingPiTag = sheet.Cells(row, 1).Value;
                var buildingTitle = sheet.Cells(row, 1).Value;
                var buildingLat = sheet.Cells(row, 2).Value;
                var buildingLong = sheet.Cells(row, 3).Value;
                var waterPiTag = sheet.Cells(row, 4).Value;
                var steamPiTag = sheet.Cells(row, 5).Value;
                var powerPiTag = sheet.Cells(row, 6).Value;
                var buildingWater = sheet.Cells(row, 7).Value;
                var buildingCoolWater = sheet.Cells(row, 8).Value;
                var buildingPower = sheet.Cells(row, 9).Value;

                //Store information in buildingData array, with the following properties
                buildingData.push({title: buildingTitle,
                                                latitude: buildingLat,
                                                longitude: buildingLong,
                                                waterPiTag: waterPiTag,
                                                steamPiTag: steamPiTag,
                                                powerPiTag: powerPiTag,
                                                water: buildingWater,
                                                coolWater: buildingCoolWater,
                                                power: buildingPower});
        }
        excel.DisplayAlerts = false;
}

function setMarkers(map, data) {
        //Define images
        var waterImage = {
        url: 'images/watericon.png',
        size: new google.maps.Size(34, 34),
        // The origin for this image is 0,0.
        origin: new google.maps.Point(0,0),
        anchor: new google.maps.Point(17, 17)
        };
        var powerImage = {
        url: 'images/powericon.png',
        size: new google.maps.Size(34, 34),
        // The origin for this image is 0,0.
        origin: new google.maps.Point(0,0),
        anchor: new google.maps.Point(-17, 17)
        };

        var waterMarkers = [];
        var powerMarkers = [];

        var powerTag  = new google.maps.InfoWindow();
```

```
                var waterTag  = new google.maps.InfoWindow();

//-------------------------------------------------------------------------------------------------
                for (var i = 0; i < data.length; i++) {
                        var building = data[i];
                        var myLatLng = new google.maps.LatLng(building.latitude, building.longitude);
                        //Marker
                        var waterMarker = new google.maps.Marker({
                                position: myLatLng,
                                map: map,
                                icon: waterImage,
                                title: building.title
                        });

                        waterMarkers.push(waterMarker);

                        powerMarker = new google.maps.Marker({
                                position: myLatLng,
                                map: map,
                                icon: powerImage,
                                title: building.title
                        });

                        powerMarkers.push(powerMarker);

                //Water Icon Click Listeners
      google.maps.event.addListener(waterMarkers[i], 'click', (function(i, building){
        return function() {
                          //On Click, change the Pi tag in Sheet2, cell(2,2) to the clicked PI tag
                          sheet2.Cells(2, 2).Value = building.waterPiTag;
                          selectedBuildingTitle = building.title + ", Water Usage";

                          drawChart();
                          powerTag.close();
                          waterTag.close();
                          getBuildingData();
                          building = data[i];

        var waterString = '<div id="watercontent">'+
                                  '<div id="siteNotice">'+
                                  '</div>'+
                                  '<h1 id="firstHeading" class="firstHeading">'+ building.title +'</h1>'+
                                  '<div id="bodyContent">'+
                                  '<p><b>Water: </b>'+ building.water + ' gpm</p>'+
                                  '<p><b>Steam: </b>' + building.coolWater +' KPPH</p>' +
                                  '</div>'+
                                  '</div>';
SRC="images/watericon.png" width="34" height="34">'
          waterTag.setOptions({maxWidth: 200});
                          waterTag.setContent(waterString);
          waterTag.open(map,waterMarkers[i]);
        }
      })(i, building));
```

```
                //Power Icon Click Listeners
                google.maps.event.addListener(powerMarkers[i], 'click', (function(i, building) {
        return function() {
                                        //On Click, change the Pi tag in Sheet2, cell(2,2) to the clicked PI tag
                                sheet2.Cells(2, 2).Value = building.waterPiTag;

                                selectedBuildingTitle = building.title + ", Power Usage";

                                drawChart();

          powerTag.close();
          waterTag.close();
          getBuildingData();
                                building = data[i];

          var powerString = '<div id="powercontent">'+
            '<h2 id="firstHeading" class="firstHeading">'+ building.title +'</h2>'+
            '<p><b>Electricity: </b>' + building.power + ' kW</p>'+
            '</div>';

          powerTag.setOptions({maxWidth: 1000});
                                powerTag.setContent(powerString);
          powerTag.open(map,powerMarkers[i]);
                                        }
                                })(i, building));
                        }
                                        google.maps.event.addListener(map, 'zoom_changed', function(){
                                                var zoom = map.getZoom();
                                                if (zoom < 18){
                                                        for (var i = 0; i < data.length; i++) {
                                                                waterMarkers[i].setVisible(false);
                                                                powerMarkers[i].setVisible(false);
                                                        }
                                                }
                                                else {
                                                        for (var i = 0; i < data.length; i++) {
                                                                waterMarkers[i].setVisible(true);
                                                                powerMarkers[i].setVisible(true);
                                                        }
                                                }
                                        });
          }
                                //-------------------------------------------------------------------------------------------
                        // Load the Visualization API and the chart package.
    google.load('visualization', '1.0', {'packages':['corechart']});

    // Set a callback to run when the Google Visualization API is loaded.
    //google.setOnLoadCallback(drawChart);

function drawChart() {
                /*excelData = [['Time', 'Water Usage (gpm)'],
```

```
                                                    [sheet2.Cells(4, 3).Text, sheet2.Cells(4, 4).Value],
                                                    [sheet2.Cells(5, 3).Text, sheet2.Cells(5, 4).Value],
                                                    [sheet2.Cells(6, 3).Text, sheet2.Cells(6, 4).Value]];*/

                var data = google.visualization.arrayToDataTable(excelData);

                //Set Chart Title based on current selected time range and current selected building
                chartTitle = selectedBuildingTitle + " - " + timeRange;

 var options = {
  title: 'Historical Data: ' + chartTitle,
  hAxis: {title: 'Timestamp'},
  vAxis: {title: 'Water Usage (gpm)'},
  legend: 'none',
                  width: 500
 };

 var chart = new google.visualization.LineChart(document.getElementById('chart_div'));
 chart.draw(data, options);
}
        //---------------------------------------------------------------------------------------

       function getChartData(range){
                var timesCol;
                var valuesCol;
                var length;


                if (range == 30){
                        timesCol = 1;
                        valuesCol = 2;
                        length = 31;
                        timeRange = "30 Days"
                }
                else if (range == 6){
                        timesCol = 3;
                        valuesCol = 4;
                        length = 6;
                        timeRange = "6 Months"
                }
                else {
                        timesCol = 5;
                        valuesCol = 6;
                        length = 12;
                        timeRange = "1 Year"
                }

                sheet2 = excel.Worksheets("Sheet2");
                excelData = [['Time', 'Water Usage (gpm)']]; //Required Headers

                for (var i = 1; i < length; i++){
                        excelData[i] = [sheet2.Cells(i + 4, timesCol).Text, sheet2.Cells(i+4, valuesCol).Value];
                }
```

```
		}

		//Change time range of chart (event: button click)
		function changeTimeRange(range) {
			getChartData(range);
			drawChart();
		}

		//Closes the background Excel file when the window is closed
		window.onbeforeunload = function(){
			excel.Quit();
		}

		google.maps.event.addDomListener(window, 'load', initialize);
	</script>
	</head>
	<body>
		<div id="ChartPanel">
			<input onclick="changeTimeRange(30);" type=button value="Past 30 Days">
			<input onclick="changeTimeRange(6);" type=button value="Past 6 Months">
			<input onclick="changeTimeRange(1);" type=button value="Past Year">
			<p><div id="chart_div"></div></p>
		</div>
		<div id="map_canvas"></div>
	</body>
</html>
```