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The SUNY College of Environmental Science and Forestry Gateway Building: An Educational and Energetic Assessment

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by

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Abstract

It has been shown that the implementation of renewable energy technologies in the building sector has the potential to achieve long-term energy and cost savings. The combined heat and power system, housed within the newly constructed Gateway Building on the SUNY ESF main campus, is in the position to increase the College's energy acquisition efficiency by 50%, when compared to the currently utilized system. The system will be constructed and displayed in such a way as to be easily understood by students, faculty and the general public- providing an array of educational prospects. Students at the College will have the opportunity to further understand the CHP system through its integration in offered coursework. The Building will also provide the means through which to expand the research of renewable energy technologies. There are a host of positive externalities associated with the Building, including but not limited to: reductions in fuel price uncertainty and increases in occupant health. Thus we have concluded that the Gateway Building has the potential to not only have a positive impact on the immediate campus community, but also on the Syracuse area as a whole.

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Introduction

The past decade has been characterized by a renewed interest in the ideal of natural resource conservation. In turn, this shift in conscious has led to the sustainable use of resources. These principles have permeated the area of building construction and there has been great care to incorporate sustainable and renewable energy systems into both newly built structures and refurbished buildings. This can especially be seen on college campuses across the United States (McInnis & Taylor, 2005). The implementation of innovative, renewable energy technologies in the building sector can achieve long term energy and cost savings (Chwieduk, 2003).

The State University of New York College of Environmental Science and Forestry (SUNY ESF) is an institution dedicated to, "advancing knowledge and skills to promote the leadership necessary for the stewardship of both the natural and designed environments" (ESF Mission statement). ESF is currently working, in conjunction with Architerra Inc., through the process of constructing a new "Gateway Building" to serve as an entrance to campus and to provide space for a myriad of activities. The Building will house admissions offices, community outreach centers, conference rooms, a state of the art fitness facility and a small dining facility.

This Building is targeting Platinum Certification in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System and will also help the College achieve its goal of reducing net carbon emissions to zero by 2015.

The Gateway Building will house a combined heat and power (CHP) system that incorporates a microsteam turbine, largely driven by biomass, and a modular power system characterized by three natural gas fired microturbines. More specifically, the

system is comprised of an 8,000 MBtu wood pellet steam boiler, an 8,000 MBtu natural gas boiler, 200 kW back pressure steam turbine, 30 kW CHP biodiesel microturbine and dual 65 kW CHP natural gas microturbines. The system is designed to convert biomass and natural gas to delivered steam and electricity. This process will produce close to 52,700 GJ of delivered energy with a projected efficiency of 76%.

This paper compares the efficiency of the new system to the purchased steam and electricity currently used by the College. The Building is designed to have three main impacts on the sustainability of the campus energy supply. First the system will significantly improve the efficiency of delivered energy. Second the system replaces fossil fuels with biomass and solar technologies. Finally, the system will produce more heat and power than it consumes, providing the campus with a source of sustainable energy. In this paper we define a sustainable energy source as those that originate from renewable resources, or fossil fuel sources, with efficiencies significantly greater than existing sources.

In addition to the in-house CHP system, there are a multitude of energy efficiency measures integrated within the Gateway Building. Increased wall insulation, utilization of skylights and daylight dimming systems, optimized south and west glazed triple paned glass windows and main floor natural ventilation are features of the Building which will further increase the energy and financial savings of the College.

The Gateway Building will also function to promote and foster teaching and research regarding energy and sustainability. The careful construction of the Building serves to showcase the in-house renewable energy system (which will be discussed in detail within this paper) and provide an educational experience geared towards students,

faculty members and the general public. Studies have shown the association between innovative renewable energy technologies and a variety of positive externalities (Jaffe et al., 2005). SUNY ESF intends to integrate the novel energy system into its academic curriculum and construct educational community outreach programs for the general public.

This paper will perform an analysis of the energy and monetary savings associated with the Gateway Building at SUNY ESF. The main question this paper seeks to answer however is, in what ways will the Gateway Building fit into research and education on and off campus and what positive externalities, if any, can be connected to the Building? What are the implications of these externalities within the ESF community, Syracuse and for the environment?

Methods

In order to fulfill the primary purpose of this paper, research must be conducted to ascertain the purpose of the Gateway Building, in terms of educational opportunities both on and off campus. This will be done through utilization of architectural renderings, prepared by Architerra Inc., in order to gain an understanding of the layout of the Building in general, which has an impact on the direct educational benefit the Building may provide to students, faculty and the general public. These materials were provided to SUNY ESF by the architectural firm. In terms of public education outreach, research will be conducted to determine what types of interpretation and publication material will be available to the general public. Contacts within the Communication and Renewable Energy Departments at ESF will be utilized throughout this process.

We will also identify research opportunities that may present themselves as a result of the construction of the Gateway Building. In particular, the combined heat and power system, housed within the Building, will be analyzed in the context of its predicted performance and its performance when compared to existing purchased energy for the main campus. Once again, educational opportunities for both matriculated as well as non-matriculated students with regard to this new technology will be investigated. In the future, the human interaction with the energy system and associated informational and data outputs will be quantified, perhaps through the use of surveys. Going a step further, the potential existence of positive externalities as a result of educational, outreach and research opportunities will be achieved through a synthesis of previous literature, as well as predicted by the authors of this paper. This research is important because it seeks to mitigate the general existence of energy market imperfections, which are focused on a lack of information regarding energy use and efficiency (Jaffe & Stavins, 1993).

As previously mentioned, a comparison between purchased electricity and steam and the combined heat and power system will provide data regarding cost effectiveness, both in energetic and monetary terms. This will be achieved though a series of calculations, diagram and flow charts. Visual media aids will seek to engage the public into thinking about energy and sustainability and the necessary linkage between the two.

Results and Discussion

Education on and off campus

Through the analysis of existing architectural documents and interviews with ESF faculty and staff it was possible to detail the purpose of the Gateway Building, in the context of what it will provide to enhance student life on campus and what it may be able

to provide in terms of public outreach. In a broad sense, the Building offers systems, designs and technologies that were constructed “beyond code”. The United States Green Building Council (USGBC) states that governments around the world rely upon baseline building codes to ensure the safety of their citizens from building related risks (http://www.usgbc.org/ShowFile.aspx?DocumentID=7403) . Buildings that are constructed beyond this baseline are done so voluntarily and are termed “beyond code”. The creation of novel technologies and innovative means through which to integrate currently existing technology function to drive demand for new materials and implementation techniques, as well as create an expansion of expertise in new areas. The construction of the Gateway Building was a means with which to test some of these new technologies, and will continue to do so in the future, with the continued use of the combined heat and power system.

Planning the Gateway Building employed a wide array of sustainable energy technologies in order to reach its goal of LEED Platinum. As mentioned throughout this paper already, the main driver of innovation will be the combined heat and power system. Increased wall insulation, skylights, daylight dimming systems, optimized south and west glazed triple paned glass windows and main floor natural ventilation, photovoltaic solar arrays and solar thermal applications are supplementary features of the Building. Additions to the campus-wide curriculum and the development of a new major, Sustainable Energy Management, were created partially as a result of the opportunities provided by the Gateway Building.

The construction process of the Building is currently being utilized in classes on campus, as students work though efficiency calculations and the cost/benefit analysis of

building a new structure versus building to code. The current Renewable Energy minor offers courses, such as Renewable Energy Systems and Biomass Energy, which will be augmented by the completion of the Gateway Building. Once the structure is completed, and the combined heat and power system functional, a multitude of educational opportunities will present themselves and students will be able to understand the energy generation process from a hands-on perspective and be able to monitor the actual system performance.

The physical representation of the core values of SUNY ESF provides the public with a rare learning experience. Existing majors, such as Environmental Resource Engineering and Landscape Architecture, and the newly created Sustainable Construction Management, degrees are supplemented by the Gateway Building and allow the public a unique look into the real-world applications of the possibly abstract coursework and curriculum offered by an environmental institution.

Furthermore, the Gateway Building opens the door for research regarding energy crops and willow biomass, which can be used in the form of fuel pellets within the CHP system. Research in these areas may result in the enhancement of current technologies, or creation of novel technologies, and create opportunities in increased efficiency, which will lead to cost savings in the long run. An increase in demand for energy crops may drive greater crop production and a subsequent increase in the market for energy crops in general. These actions could make energy crops a more viable and widespread energy alternative in the future.

Positive and Negative Externalities Associated with the Gateway Building

An externality is defined by Merriam Webster as, "a secondary or unintended consequence". Externalities can be either positive or negative, and are not associated with direct economic costs or benefits. Instead, the impacts of externalities are indirectly felt by those who may not be directly associated with the operation, therefore may not be adequately represented during the planning and implementation process. Due to this fact, it is important for conscientious entities to attempt to maximize positive impacts of a process and mitigate the negative.

Our research has shown that the intended positive impacts of the Gateway Building will far outweigh the negative impacts. During the construction process, there are many important "behind the scenes" players that are often overlooked, perhaps to favor expediency. Large energetic costs are associated with the transportation of building materials. If orchestrated sustainably, these costs can be dramatically reduced and simultaneously stimulate the local economy. The current volatile fluctuations associated with fossil fuel utilization can introduce uncertainty regarding pricing of construction materials, as well as utilities. By purchasing materials from a local industry, these fluxes can be partially counteracted, as shipping costs will be dramatically reduced.

Architerra Inc. and SUNY ESF have worked in conjunction to design and construct a building that will be "unable to be replicated". These words, spoken by Mr. Simon Shaw (architect at Architerra Inc.), are a testament to the degree of detail that the Gateway Building houses. ESF has attempted to utilize local materials whenever possible during the construction process, however due to stringent NYS procurement laws it has been difficult to reach the lofty goals that Architerra and ESF initially set. However, ESF

is poised to work with Roberts Office Furniture Concepts, out of Liverpool, NY, to provide recycled furniture for the Gateway Building. Roberts obtains furniture from the 1980's and 1990's, which is oftentimes built more durably, and repurposes it for resale and reuse.

Opportunities to create further energy savings and cost reductions may arise due to the fact that ESF chose to utilize wood pellets as the main renewable energy resource for the CHP system. The system is projected to produce enough ash waste to fill a 55 gallon drum per day. This ash will be utilized on campus as a fertilizer, reducing the carbon footprint of not only fertilizer production but also material transport.

Fluctuations in oil and gas pricing can contribute to uncertain utility costs, which impact the payback period of a building once it is constructed. Over utilization of fossil fuel resources, allowed by the traditionally unregulated market, can cause the under-use of renewable energy alternatives (Gillingham & Sweeney, 2010). ESF hopes to combat this phenomenon via the CHP system. By relying upon the CHP system, which is fueled primarily by wood pellets and supplemented by natural gas, both variations in pricing and the overall operation cost of the facility will decrease. The Gateway Building provides steam for four campus buildings, apart from itself, so the associated reduction in energy cost will have a greater impact the campus than simply adding a new efficient building. The four buildings which will receive thermal and/or electrical energy from the Gateway Building are: Baker, Jahn, Illick and Moon Library.

Due to cost saving features and the utilization of a wide array of renewable energy technologies, the Gateway Building will boast a higher overall value, in both present and future terms. The Gateway Building and systems demonstrates the opportunity for

financial, energy and environmental savings, which should foster the adoption of similar green technologies elsewhere. As green technology becomes more mainstream, it's value should begin to be recognized in real estate markets and make buildings such as the Gateway Building more profitable (financially, socially and environmentally). Similarly, by constructing a green building, before it is a required measure, SUNY ESF is gaining further recognition as a leader in the "green" construction field and securing its spot as a major player in the environmental movement.

In a more tangible sense, the Gateway Building may function to help increase occupant health, by increasing air quality above current campus building standards. Increases in air quality are associated with increases in overall health and wellbeing as well as lifetime medical bill reduction. The Gateway Building will also provide increases in natural lighting available to occupants. Greater access to daylight should provide increases in overall health as well as wellbeing (Edwards & Torcellini, 2002). The impact of the Gateway Building on surrounding areas will be lessened due to the high degree of efficient technology employed within the Building. Reductions in noise pollution, air pollution and undesirable smells will be achieved as a result of the Building, increasing the quality of life of those both utilizing the interior and exterior of the Building.

A negative externality of constructing a green building is the increased time and human energy needed to develop and implement the technology. Public support and zeal may be degraded over time if a project takes too long to plan or complete. There is also an opportunity cost associated with the construction of a building of any type and the Gateway Building does not escape this. By constructing a building on previously open

space, SUNY ESF is eliminating the usage of this land for something else in the future (ex: park or recreation area). However, the College was previously using the space for the Building as a parking lot, therefore recreational land was not directly lost. The vehicles that used to occupy this space have been redirected to parking lots (with pervious pavement) in proximity to a different building on campus, as well as integrated into existing parking near campus.

In conclusion, the price of energy consumption and building construction is not normally reflective of its full social costs (ex: pollution, extraction costs, refining costs), but SUNY ESF has sought to internalize some of the negative externalities normally associated with traditional building practices. This reduces the need for subsidies and spurs technological development, instead of prolonging "business as usual" approaches.

Increases in Energy Efficiency

In total, the SUNY ESF campus annually requires approximately 55,000 GJ of steam and 38,600 GJ of electrical energy to function. The Gateway Building produces 52,700 GJ of energy annually. This is broken down to about 43,300 GJ of thermal steam energy and 8,400 GJ of electrical energy. Thus the Gateway Building is projected to provide the campus with 78% of its thermal energy needs and 22% of its electrical energy needs. This produced energy will provide services to 4 buildings on campus, not including the Gateway Building. Therefore, the CHP system was designed to meet the needs of 5 buildings on the SUNY ESF campus.

SBefore the Gateway System, the College purchased power from an outside entity. At this power plant, 73,800 GJ of natural gas energy was input to the system at an efficiency of 58%. This results in a delivery of 42,100 GJ of steam to SUNY ESF and an

associated loss of 31,600 GJ. For electricity generation, 24,300 GJ of natural gas energy was input into the system at an efficiency of 34%. This results in a delivery of 8,400 GJ of steam to the College and an associated loss of 16,300 GJ (Figure 1). Overall, this process has a total efficiency (weighted average) of 52% (Figure 2).

The Gateway system has a much greater projected efficiency than the system used by SUNY ESF in the past. The Gateway system utilizes a steam boiler and a dual microturbine system to produce 43,300 GJ of thermal energy and 8,400 GJ of electrical energy, with associated losses of 16,900 GJ (Figure 3). This calculates to an overall system efficiency of 76% (Figure 4). When compared to the older system, this represents a 24% rise in efficiency, or a system that is 50% more efficient than the previous. Furthermore, the CHP system is operated on 55% renewable fuel pellets, which are partially produced in the Central New York region. In the future, ESF hopes to purchase pellets that are fully produced in the CNY region. This utilization of local resources reduces the carbon footprint of the entire process, aids in the integration of renewable energy into the region, raises awareness of renewable energy in general and supports the local economy.

The results of the CHP system's performance will be made publically available though the utilization of display boards, web content, brochures/fliers and through further publications. It is common practice to remove power generation systems from the public eye because they are perhaps not the most glamorous or aesthetically pleasing piece of technology. However, ESF will have its system on display to the general public via large viewing windows. The system will be color coded, by major component part, for ease of identification. A large identification key will accompany the viewing area, so that visitors

may gain an understanding of what is generating the power they depend upon. In conjunction with the color coded system, electronic displays will show real time and historic energy flows in the Building and energy system. This information will also be available on the SUNY ESF website. Main level display of all the sustainability features in the Building will include a flow chart showing energy savings.

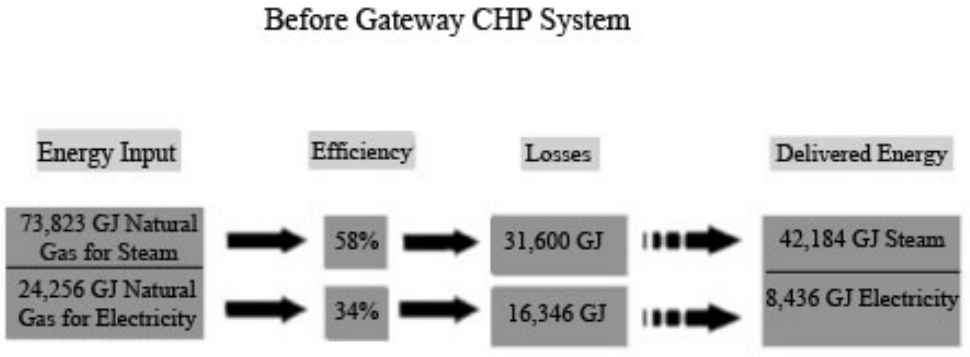

Figure 1: Energy inputs and delivered energy outputs for steam and electricity generation, with associated efficiencies and losses, prior to the utilization of the CHP system, housed within the Gateway Building.

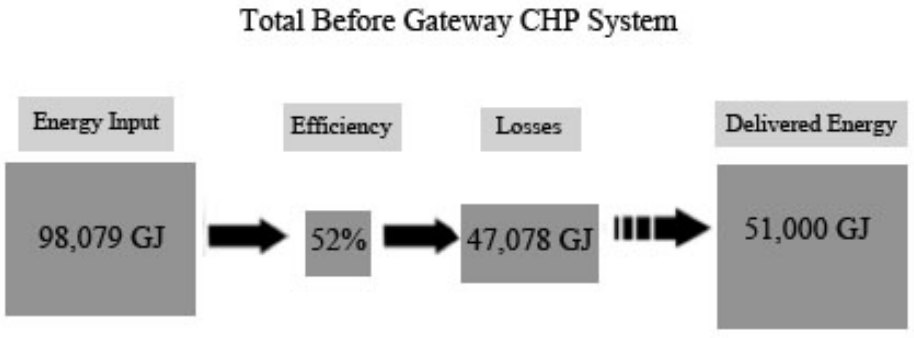

Figure 2: Total energy inputs and delivered energy output for steam and electricity generation, with the associated efficiency and loss, prior to the utilization of the CHP system, housed within the Gateway Building.

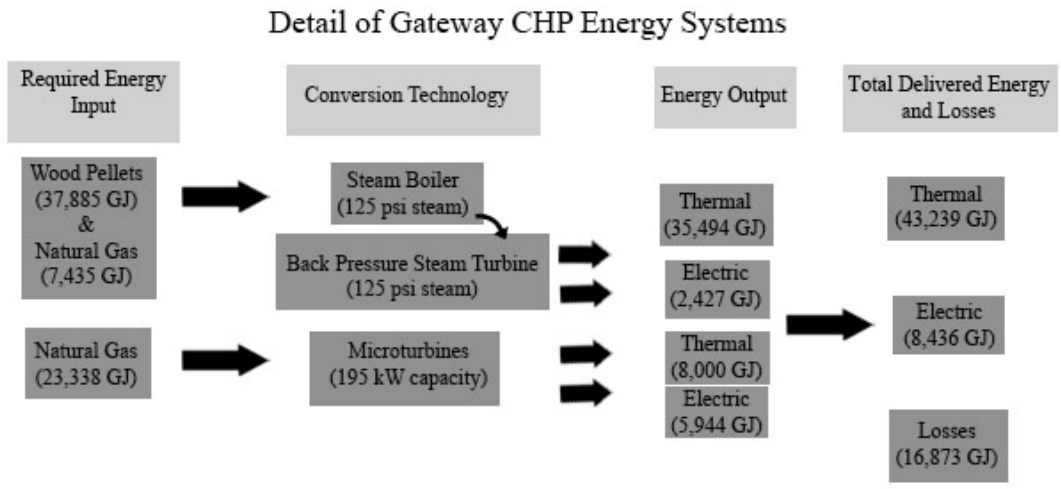

Figure 3: Required energy, conversion technology, energy output and losses of gateway CHP system.

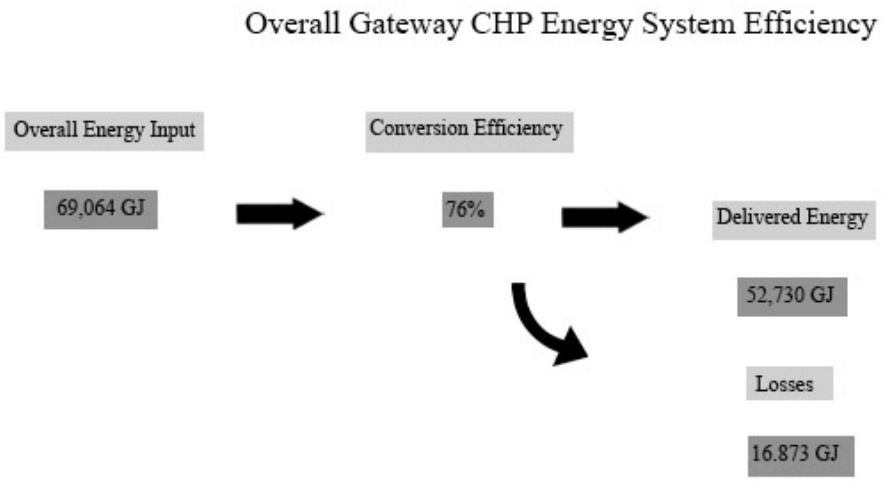

Figure 4: Efficiency, delivered energy and losses of Gateway CHP System.

Conclusion

The Gateway Building was constructed to be the physical representation of what SUNY ESF embodies as an institution. As was shown in the three preceding sections, the Gateway Building has the potential to provide educational opportunities to students and visitors both on and off campus, provide external secondary positive benefits, as well as increase the efficiency of energy acquisition at the College.

The combined heat and power system will be showcased within the Building and provide all who come in contact with it the opportunity to understand its functioning and output, via visual media and web content. The College's curriculum will be enhanced by the presence of a large-scale renewable energy technology application. The positive externalities associated with the Building will further improve the quality of life on campus, as well as educate the general public on matters regarding renewable energy. The Building will provide thermal and electrical energy to 5 buildings on campus, including itself. This energy generation represents 78% of the total campus thermal needs, as well as 22% of total electricity needs.

Finally, the Gateway Building has a positive impact on the Syracuse community and the environment as a whole due to two separate sets of externalities. On a small scale, the decrease in emissions, which are a result of shifting from fossil fuel based energy delivery to renewable energy production, will have a positive impact on the local community in terms of health and wellbeing. On a larger scale, the CHP system will provide the general public with knowledge of the creation and benefits of renewable energy technologies. This information can be applied elsewhere, for example in

residential buildings or on a more industrial scale, expanding the number of projects similar to the Gateway Building. We term this: compounding externalities.

In providing these renewable energy options and educational services to a variety of people, the Gateway Building is poised to be a desirable academic and educational asset, providing the College with a series of positive returns in the future.

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