Spring 5-16-2014

Building a Better Office of Sustainability: Promoting Sustainable Change and Educational Outreach at WKU

Andrew Salman
Western Kentucky University, andrew.salman145@topper.wku.edu

BUILDING A BETTER OFFICE OF SUSTAINABILITY: PROMOTING SUSTAINABLE PRACTICES AND EDUCATIONAL OUTREACH AT WKU

A Capstone Experience/Thesis Project

Presented in Partial Fulfillment of the Requirements for

the Degree Bachelor of Science with

Honors College Graduate Distinction at Western Kentucky University

By

Andrew Salman

*****

Western Kentucky University
2014

CE/T Committee:

Dr. Judy Rohrer, Advisor

Christian Ryan

Wolfgang Brauner

Approved by

____

Advisor
Department of Diversity
and Community Studies

ABSTRACT

This research documented the transformation of the house at 503 Regents Ave. in Bowling Green KY into a model home of sustainability by the WKU Office of Sustainability as a case study. Using the Leadership in Energy and Environmental Design (LEED) Core Concepts, the benefits of weatherization (window upgrades, insulation, sealants) to the building, the addition of a solar energy array and utility grid intertie, and the transformation of the back yard into an edible landscape and community garden to mitigate stormwater flooding issues were assessed. Collaboration between the Office of Sustainability, students, university entities, and community members were encouraged and documented as a record of activity. Procedural and Institutional barriers to sustainability initiatives, such as liability insurance for solar arrays installed on commercial or public buildings, were analyzed for solutions or workarounds. Exceptional results, such as the collaborative community gardening organization Project Grow, are described to serve as a model to other institutions.

Keywords: sustainability, green building, Leadership in Energy and Environmental Design, renewable energy, community gardening, community organizing.

Dedicated to my mentor, Courte Voorhees.

ACKNOWLEDGEMENTS

The success of this project is due to the cooperation of many people. As this cooperation is both extensive and the subject of the study itself, not all people and groups can be included here. It is, however, with the support of John Osborne of Campus Services and Facilities and Dr. Gordon Baylis of the Office of Research that we at the Office of Sustainability have the space which enabled this research. Thanks are also due to the Department of Diversity and Community Studies for their continued support of the work of the Office, and for indirectly supporting this project by awarding me the Global Pathways to Sustainability Scholarship.

Also due to thank are the groups who have made the space successful by utilizing it. Various faculty, along with student organizations like WKU Americans for Informed Democracy and students like Elizabeth McGrew and Mary Boothe are the reason the Office is around and that 503 Regents is worthy of study.

Finally, I would like to thank Dr. Courte Voorhees for helping me shape this project in its infancy, Dr. Judy Rohrer for providing extensive critical feedback on drafts, and Christian Ryan for supplying the work which I studied and answering every odd question sent to her in the middle of the night while trusting that it was relevant to this work, even if not apparently so.

VITA

December 13, 1992 ....Born-Honolulu, Hawaii

2010..Allen County-Scottsville High School
Scottsville, Kentucky

2012..Research Assistant,
Youth Leading Environmental Change
Wilfred Laurier University

2012..Teaching Assistant,
ICSR-301: International Environmental Justice

2013..Recipient, Global Pathways to Sustainability Scholarship

FIELDS OF STUDY

Major Field 1: Political Science

Major Field 2: Biology

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This document marks the completion of two and a half years of work towards an Honors Capstone Thesis Project. Over this time, Christian Ryan, Coordinator for Sustainability, I, and many others have worked together to renovate a building on campus into a model home of sustainability and document and evaluate the changes made.

I first met Ryan in a course I was co-leading on food deserts and the local international community. It was from my meetings with her and my experiences watching her speak about local food and its role within sustainability with great enthusiasm that I decided with my advisor, Dr. Courte Voorhees, that my project was to be one that involved the Office of Sustainability, though the specifics had not been worked out at the time. It was serendipity, then, that the Office acquired the property at 503 Regents Ave, the summer following Ryan and I's first meeting.

The Office of Sustainability

Founded in 2007, the Office of Sustainability (hereafter referred to as the Office) serves the WKU community by encouraging environmentally conscious practices that improve the quality of life in Bowling Green. The mission of the Office is "to promote a culture of sustainability at WKU, integrating principles of ecological integrity and social equity into academics, practices, and partnerships," and its goals are to "ensure that WKU is an institution that provides innovative solutions to global challenges, prepares students as engaged and responsible citizens, and observes best practices in campus operations and services."

The Office still has only one paid staff, the Coordinator, and receives a minimal annual operating budget—instead the Office relies on creative funding methods or support from other departments. This will factor greatly into which projects are pursued with respect to 503 Regents, as each one essentially requires the approval and buy-in of another entity, whether it be a university or community sponsor.

Introduction to the House

The house at 503 Regents Avenue, Bowling Green, KY (hereafter referred to as 503 Regents) was acquired by the WKU Office of Sustainability in the summer of 2012. Early in the summer, Christian Ryan, Coordinator of Sustainability, was contacted by John Pace, experienced bee-keeper and Manufacturing Support Specialist for the Department of Architecture and Manufacturing Sciences, who was commissioned to remove a hive of bees that had settled in the walls of the front of the house. Pace determined that relocating them to the bee hives at the WKU Agriculture Farm was the ideal plan of action, and requested that Ryan come to oversee the move as a way of documenting environmentally-conscious solutions being enacted at WKU.

Ryan was at the time searching for a larger space than the single room in the Facilities Management building that currently housed all of the Office's operations, including Big Red Bikes and the TVA Powersave Interns. Seeing the unoccupied house at 503 Regents prompted Ryan to propose to John Osborne, Vice President for Campus Services & Facilities, that the building be granted to the Office. University administration had plans to turn the home into an apartment to be rented out for revenue, but after Ryan submitted a proposal of her plans for the home to become a model home for sustainability, along with an agreement from Dr. Gordon Baylis, Vice President of Research and President of the WKU Research Foundation, that his office would cover half of the rent for the house during its time housing research projects by the Office of Sustainability, Osborne agreed to cover the remaining rent and placed a bid for the space.

This bid did not come uncontested. As a growing institution WKU, chronically lacks the space to adequately house all of its components, and multiple entities on campus had requested the space. Ultimately, the house was granted to the Office of Sustainability on the grounds of Ryan's initial proposal. The house was to be occupied by the Office for one year without any changes made to the infrastructure. This would allow the gathering of baseline data, after which projects exploring best practices in building construction, maintenance, and operations would be conducted with the goal of scaling up successful projects to larger parts of WKU's campus. During the time, the office was to also cooperate with community entities as a demonstration home and place of continuing education about sustainable best practices.

While the rent for the home is paid for by the Offices of Facilities Management and Research, and utilities are billed to the university, the projects for improvement of the home came with no budget—it was and remains the responsibility of the Coordinator of Sustainability, Ryan, to acquire funding for these projects on her own. This has largely been done by cooperating with commercial providers of the materials used by the Office to get services and materials prorated or donated entirely in exchange for donor status and in-house advertisement alongside displays that explain the projects. When materials could not be acquired free of charge, grants were applied for to cover any remaining costs.

Many small renovations were made immediately, just to address factors associated with the building sitting unoccupied for an extended period and to prepare the building for data collection. These included replacing the wall from which the bees were removed, repainting the entire interior of the house with low-VOC (volatile organic compounds) paints, moving the Big Red Bikes maintenance equipment into the building, connecting the building to WKU's network for telecommunications and internet, and replacing broken or expired light bulbs with new compact fluorescent light bulbs. An Eaton IQ 35M energy meter was installed to measure all energy use and production, and the meter was connected to the campus-wide energy management system, Johnson Controls' Panoptix® dashboard, which enables access to detailed energy reports specific to the house.

With these changes in place, 503 Regents became the home of the Office of Sustainability, Big Red Bikes, TVA's Powersave Interns, various student organizations including WKU AID and Greentoppers, and began its baseline year for data collection in September of 2012 and concluded it in October of 2013.

<u>The Project</u>

The overall goal of this project is to use a case study of the remodel of 503 Regents to document, explore, and analyze improvements to homes that limit the home's ecological impact while improving the environmental quality of the space. Secondary goals include 1) identifying policies that discourage the adoption of sustainable practices in order to advocate for the elimination of institutional barriers to sustainability and 2) encouraging student research on sustainability and engagement with the space.

These goals align themselves with the Office of Sustainability's function to "engage university wide stakeholders to develop policy and to identify and implement best practices to institutionalize sustainability principles and goals." This project will also record the ways that the space is designed and used to "encourage cross-campus collaboration and partnerships, bridging academics and operations using the campus as a living laboratory where ideas can be practically implemented." Coordinators of the renovations to 503 Regents pays special attention to the engagement that students are investing into the Office of Sustainability, as well as the tangible products of these collaborations that can be shared with the university community at large.

This project furthers the Office's mission by creating space to highlight sustainable practices and to educate students and visitors about them. This project contributes to the Office's goals by experimenting with new solutions for sustainability-based problems facing the campus and by creating spaces and opportunities for students to engage in sustainability-based projects, like community farming and "PowerSave" internships with the Tennessee Valley Authority.

Ryan has observed that no other university or Office of Sustainability has taken on the task of remodeling a building for the purpose of using it as a sustainability demonstration home. Others have created new, hyper-efficient solar buildings, such as the North Carolina Solar Center at North Carolina State University or the Florida Solar Energy Center at the University of Central Florida, but none have taken on the task of maximizing the efficiency of a pre-existing building. As a demonstration home, this is important because few people have the resources to create hyper-efficient, net-zero buildings to occupy—many people inherit homes and other buildings from generations prior and have to make do. By demonstrating how to maximize the resources present, this project seeks to introduce a far larger audience to sustainable building and remodeling practices, and hopes to have a larger impact by doing so.

In addition to within this document, selected work of the Office of Sustainability will be communicated to visitors to the Office by way of interpretive signage, which will highlight the sustainable features of the space and explain their significance. This thesis document, the interpretive signage, and my accreditation as a Leadership in Energy and Environmental Design (LEED) Green Associate, comprise the Capstone Experience project.

Organization of this Document

This thesis is organized to emulate the process an initiative within the Office of Sustainability undergoes when put into action. Informed by the goals and principles of sustainability, a successful initiative would be researched and given an experimental trial before being introduced to the campus at large. This chapter and the next aim to contextualize the work being done at 503 Regents both in the university environment as well as in principles of sustainability. Due to the university's experience and commitment to LEED principles, these were used as the guiding best practices to determine which initiatives were pursued and how.

Chapters 3, 4, and 5 will look at specific issues that have been addressed in the improvement of the house. In each chapter, the problem will be defined, the initiative designed in response will be described, data collected will be interpreted, and the overall "sustainability" of the initiative itself will be assessed by systems-wide and life-cycle analyses. The remaining chapters will detail the local community's investment in the space and the benefits the space has to provide them, analyze the collaboration of the many arms of the university to ensure the quality of the space and the work done therein, and institutional roadblocks that discourage innovation in sustainability or the adoption of sustainability best practices on a larger scale. The concluding chapter will synthesize information from the prior chapters in order to demonstrate the significance 503 Regents holds for the university and community, as well as to offer predictions on the future of the space and the Office's work.

CHAPTER 2

CONCEPTS IN GREEN BUILDING

There is a wealth of literature on sustainability and how to approach it, especially within green building. Many times, the great diversity of concepts and approaches present in the field can obscure meaning and goals as much as clarify. In this field more so than many others, it is necessary to detail what frameworks and approaches are being used to ensure common meaning and goals. For this reason, this chapter aims to clarify the approach used within this document as well as by the Office of Sustainability by discussing sustainability and its definitions, the Triple Bottom Line, and Leadership in Energy and Environmental Design (LEED) Core Concepts.

Sustainability is a broad concept that is difficult to define. It is most commonly mentioned as an antidote to issues such as global climate change, pollution, wasteful resource consumption, and irresponsible land use. The common connecting concern between these issues could be described as them limiting the gross productivity of the earth in the future, whereas sustainability offers the opposite. Sustainability is best understood as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs," as it is defined in the Brundtland Report (World Commission on Environment and Development, 1987).

Current resource extraction and manufacturing processes have broad impacts, environmentally and socially. Byproduct pollutants and toxins adversely impact human health and ecological systems including air, water, and soil. Rapid consumption of nonrenewable resources prevents our access to them in the future, running directly counter to the Brundtland Report's definition of sustainability. Wasteful land management (e.g. urban sprawl) degrades spaces that could be more efficiently used to meet the needs of society and can eliminate their capacity to produce for centuries to come (e.g. rainforest deforestation).

Global climate change is the most complex and far-reaching negative effects of our society's unsustainable habits. The science on global climate change identifies four main impacts: limiting the ecological productivity of ecosystems in such dramatic ways as desalinating marine water and upsetting marine life (Roessig, Woodley, Cech, Jr. & Hansen, 2004); changing the growing seasons and geographic distributions of plant life (Ibáñez, et al, 2010): creating more powerful weather systems (Holland & Bruyère, 2014); raising the mean sea level (Etkins & Epstein, 1982) and otherwise disrupting critical ecological cycles. These factors reduce the ecological potential of the earth, both by reducing access to resources such as fresh water and food that living organisms need, and by creating environmental conditions which our societal infrastructure is unequipped to handle.

It is these impacts of global climate change that the field of sustainability seeks to address. Most pressing in today's world are the great rate at which we are exploiting fossil fuels, which are nonrenewable and for which we currently lack a sufficient alternate infrastructure with which to produce energy in their absence, as well as which release large amounts of atmospheric pollutants and greenhouse gases, contributing to global climate change. Our extremely inefficient use of land, such as urban development which sprawls and inefficiently uses space, compartmentalizes, such that few small, local spaces are self-sufficient. A common example of spaces that are exceedingly non-self-sufficient are food deserts—areas with low median family incomes that lack easy access to affordable or healthy foods (US Department of Agriculture Agricultural Marketing Service) —which the Office of Sustainability has cooperated with the Institute of Citizenship and Social Responsibility in the past to combat in Bowling Green. Resource extraction and manufacturing and agricultural processes and practices necessitate transportation of materials over great distances, the associated costs of which are often externalized, in the form of a diversity of environmental damages and social injustices.

Due to the multifaceted effects of both pollution and global climate change, fossil fuel consumption and inefficient land use will be some of the primary issues to be addressed by projects at 503 Regents. These environmental goals will be pursued alongside the community and educational goals of the space. The three projects highlighted in the following chapters seek to meet these fuel efficiently and land use goals. The first project closes the building envelope to decrease the need to use natural gas or refrigerants to manage the climate of the space. The second project creates solar power to reduce the amount of fossil fuel consumed to power the space as well as to produce clean energy to be shared with other BGMU clients. The third project transforms the landscape around the Office to function in alignment with ecological principles and to produce local food to reduce WKU students' reliance on non-local, corporately-sourced food and its associated transportation costs.

The Triple Bottom Line

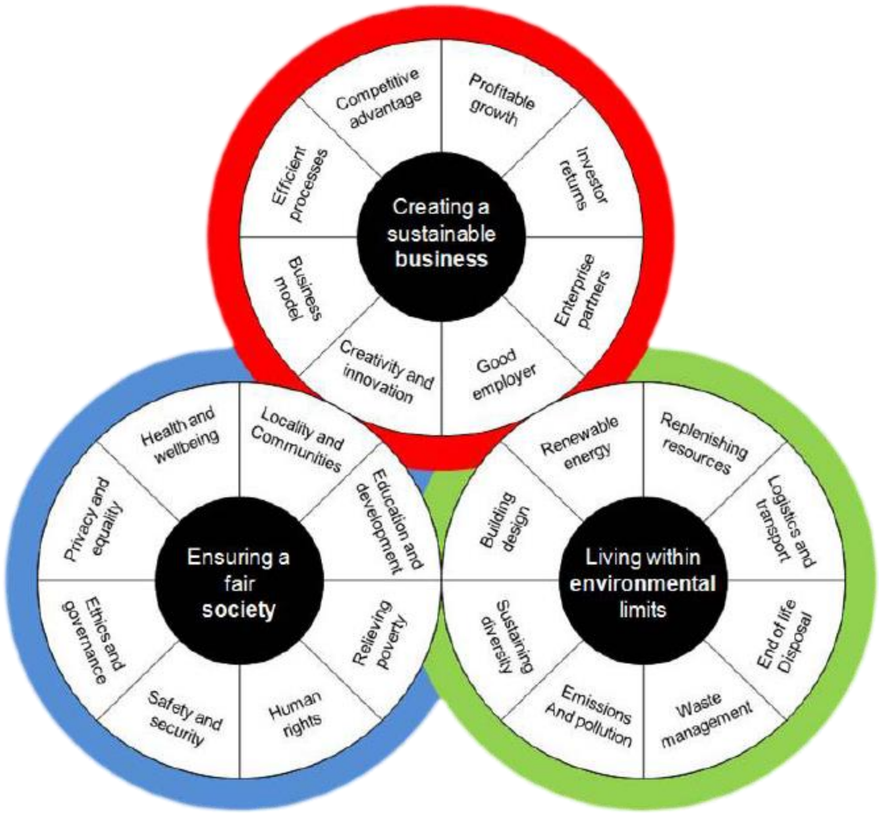


Figure 2.1, The Triple Bottom Line. Source: Stallings, R. (2013, January 06).

If there is one framework that could be considered the standard for informing and contextualizing work in sustainability, it is the Triple Bottom Line. First described in 1998 by John Elkington in *Cannibals with Forks: the Triple Bottom Line of 21st Century Business*, the Triple Bottom Line takes the traditional economic meaning of "bottom line"—the net profit or loss of an endeavor—and expands it to account for economics, ramifications for social equity, and environmental effects (Elkington, 1998). These categories, often shortened to "People, Planet, Profit," together stress that changes positively affecting the environment, if they are to be adopted on a large scale, must prove to not be outweighed by losses to profit or social conditions, and that oftentimes a single change can be beneficial to all three fields simultaneously.

Since its introduction, the Triple Bottom Line has been adopted as the primary conceptual framework for evaluating sustainable initiatives by such influential institutions as the United Nations ("Enhancing the role," 2011) and the US Green Building Council (U.S. Green Building Council, 2011). These adoptions make the Triple Bottom Line a very useful tool for communicating common meanings in a field where definitions and concepts are constantly changing.

This does not leave the Triple Bottom Line without critique, however. One major criticism is that while this framework, in theory grants equal weight in decision-making to all three categories, in practice it grants greater consideration to economic concerns than environmental or social concerns. While losses to either of these latter two categories can be excused if great benefits can be demonstrated in the other categories, this does not appear to be the case with economic losses. The notion that economic growth must be remain uninterrupted through efforts to improve environmental conditions is problematic, as it was unchecked economic growth and a ubiquitous culture of consumption to which many of the current environmentally deplorable conditions and practices can be attributed. Abstract metrics for assessment and the necessity of financial growth have led to accusations of the Triple Bottom Line being used as a mechanism for compliance (Sridhar & Jones, 2013).

With these concerns in mind, it should be said that the flaws within the Triple Bottom Line conceptual framework are most evident in large scale analyses at the national or corporate levels. At the individual and community levels of analysis, pursuing social and economic equity while primarily striving to be better environmental stewards is a laudable, and perhaps essential, framework for evaluating progress and success. This is true because those individuals and communities that are most susceptible to negative environmental factors are significantly more likely to come from backgrounds of low socio-economic status, meaning that a reduction to income or social equity for the sake of environmental benefits is more likely to have disastrous effects for those involved.

In its largest and simplest permutation, environmental sustainability is about maintaining and improving quality of life for ourselves and future generations. Seemingly impossibly large issues, like global climate change and air, water, and soil pollution, are contextualized and have their importance communicated by how they create more difficult conditions in which humans must live. Actions that reduce long-term quality of life must be discouraged while our culture is shifted towards one of sustainability as opposed to consumption (Sridhar & Jones, 2013).

Leadership in Energy and Environmental Design

When it comes to green building, there are dozens of competing standards and approaches that can be used to reduce the environmental impact of a site. Many are innovative and can produce structures with phenomenally low impact on the environment, such as the Earthship model, which heats passively while filtering its own water and producing food for its inhabitants, or the PassivHaus, which use airtight construction to eliminate the need for space heating or air filtration. These programs have strict requirements and must be built specifically to the provided specifications. On a university campus, and especially for an already-existing building, a greater degree of adaptability is required. Recently, the Living Building Challenge has been gaining popularity for its requirements, which are similar but more stringent than those of LEED (Leedham, 2011). Despite this, the LEED framework is still considered a standard in the field of sustainable development, stresses interrelationships between environmental factors, and accounts for community impact in addition to site-specific impact. Most of all, it offers many approaches to reducing the impact of a building on its site that can be chosen from to suit the needs to the building and the site.

WKU and those involved in this project have past experience with LEED projects, so using LEED helps promote a common understanding of goals and a shared vocabulary between stakeholders. Specifically, in 2009 WKU has pledged that any new construction on campus will be certified to at least a LEED Silver rating (Osborne, 2009), the Sustainability Coordinator, Christian Ryan, is a LEED Accredited Professional, and I became a LEED Green Associate as part of my work on this project.

LEED standards break sustainability into five broad categories that can be used to assess the sustainability of a building. These categories are Energy Efficiency and Source, Water Conservation and Treatment, Material Efficiency and Effects, Indoor Environmental Quality, and finally Site and Community Impact.

LEED publications that focus on the first three categories, Energy, Water, and Materials, all maintain similar themes, goals, and organizations. In general, the less of any one thing that is consumed, the better. If consumption is necessary, the efficiency of the resource's use and its long-term impacts are also considered. While these categories heavily emphasize the “Planet” third of the Triple Bottom Line (benefits to People, Profit, and Planet), the rationale is generally embedded in Profit. Reductions in energy, water, and maintenance lower operating costs, making them an attractive choice when Return on Investment is used as an evaluating metric.

Alternately, Site and Community Impact concerns itself more with systemic evaluations that analyze the ways that the preceding three concepts interact with the area surrounding the site to ensure that no change negatively impacts the environmental health in a way that would not be accounted for within the framework of the preceding three concepts alone. Finally, Indoor Environmental Quality is used to ensure a high quality of occupant health and safety. Low-VOC (Volatile Organic Compound) paints, sealants, and finishes, along with ecologically friendly cleaning supplies and good air circulation make the buildings more livable and attractive to residents. If resource-saving initiatives impede the ability of occupants of a building to complete their work or compromises their comfort to an unreasonable degree, those concerns would be reflected in evaluations of this category.

With energy, the first principle is simply to use less. Any design choice that uses less energy than its alternative is generally preferable. After this, the source of the remaining energy becomes a concern: renewable and low-impact energy sources such as solar, geothermal, and wind are preferred over non-renewable resources which are more resource-intensive to obtain and create pollutants that can affect other criteria like Indoor Environmental Quality and certainly Site and Community Impact (LEED, 2009).

Water's first principle is to reduce disruption to hydrologic cycles. By drawing water away from areas that would receive it naturally, and allowing it to accumulate in environments unequipped to process large quantities of water, we disrupt the natural systems that filter and provide communities with their water, as well as destroying the productivity of the surrounding environments. Next, reducing the amount of potable water (water treated for human consumption) used is considered, as potable water treatment and movement is a very high-impact and costly process. Because of this, strategies that highlight rainwater and greywater (domestic wastewater unfit for human consumption, but does not contain human waste) collection and reuse are paramount to water conservation (LEED, 2009).

Finally, materials used in building and maintaining the home should be minimized when possible, obtained from renewable sources, and integrated into the building in a way that has as small an impact on the site as possible. Materials whose retrieval or production is low-impact, and which do not contain compounds disruptive to human or environmental health are to be used over their counterparts whenever possible. For example, Forest Stewardship Council certified woods are preferred to those that are not certified due to the attention to sustainability and ethical forestry that is guaranteed by certification, and cellulose insulation to fiberglass insulation due to the decreased embodied energy discussed further in Chapter 3. Finally, maximizing the efficiency of each material and minimizing or eliminating waste through efficient use and recycling are goals to be considered (LEED, 2009).

These three fields are synthesized and expanded upon in Site and Community Impact. Standards in sustainability stress processes known as “Systems Thinking” and the “Life Cycle Approach” for this reason. Systems thinking promotes the broad evaluation of how a design choice affects all of the systems in the surrounding infrastructure and environment. The life cycle approach considers the source of a resource, its lifespan, and how it must be disposed of in order to better understand its relative sustainability. To meet these considerations, local, long-lasting, and recyclable materials and installations that complement or at least do not disrupt each other are preferred. Together, these considerations help to minimize the disturbance a building project makes in the immediate environment and in global systems (LEED, 2009; "Life cycle assessment," 2013).

CHAPTER 3

BUILDING ENVELOPE

More than half of all US residences use natural gas to heat their homes, including 503 Regents. After the 57% using natural gas, the next largest group, 25%, uses electricity which may or may not be predominantly fossil fuel-sourced. By upgrading the building envelope to allow the heating system to be downsized, residences can reduce their carbon emissions by 20-50% (US Department of Energy, 2012). This chapter serves to analyze how the Office of Sustainability improved the integrity of 503 Regents' building envelope and the benefits it reaped from doing so. After exploring the 503 Regents' building envelope's problems, this chapter will offer an explanation of the solutions implemented, data gained from testing the envelope, and the ecological impacts of the Office's solutions over their lifetime.

Along with considerable environmental impacts, reducing the workload on heating and cooling systems offers large returns on energy bill savings. 45% of a home's energy use and 54% of the energy bill, on average, comes from heating and cooling (Matulka, 2013). Improving on these systems offers a large margin of return on investment, both financially and environmentally, while also improving the Internal Environmental Quality of the space by increasing thermal comfort and reducing airborne allergens circulated through the home.

Definition of Problem: A Leaky Building Envelope

The building envelope is the combination of building factors which physically separate the interior environment from the exterior environment and mediates their relationship. It does this by selectively allowing air and other elements to pass through it. In *The Building Systems Integration Handbook*, author Richard Rush describes the role of the envelope as such:

> The envelope has to respond both to natural forces and human values. The natural forces include rain, snow, wind and sun. Human concerns include safety, security, and task success. The envelope provides protection by enclosure and by balancing internal and external environmental forces. To achieve protection it allows for careful control of penetrations. (Rush, 1991)

For the purposes of this project, the building envelope is comprised of the exterior walls, roofs, and all fenestrations (windows, doors, atria, etc.). The Whole Building Design Guide (WBDG) enumerates the specific roles of a building envelope as such: to resist water penetration, condensation on interior surfaces, excessive air penetration, and thermal transfer; to limit sound transmission, and enable daylighting—all while also supporting building infrastructure, resisting fire, and enabling the security of occupants (Arnold, 2009). With 530 Regents, we were most concerned with the envelope's roles in limiting air transference and thermal regulation.

The WBDG specifies that the building envelope should limit “excessive air penetration” because too tight of an air seal can have detrimental effects on internal air quality (Choate, 2013). This is a problem that is encountered in many newer buildings, but is not anticipated to ever be a factor in the Office of Sustainability. The inverse—too great a degree of air penetration—limits the efficiency of occupant control of climate and therefore comfort. Maintaining comfortable environmental conditions therefore requires a greater input of energy in the form of more frequent and intensive air conditioning or heating. This dramatically increases energy consumption (the Office uses natural gas for heating), the costs to maintain the building (in the form of a larger HVAC system and more frequent maintenance thereof), and generally decreases indoor environmental quality.

Blower Door Testing demonstrated that 503 Regents' building envelope is exceedingly leaky, meaning that airflow between the outside and inside of the building is more common than is desirable. This frequent circulation of air forces heating and cooling systems to frequently condition new air that has entered the building while previously conditioned air escapes to the outside, increasing the workload on the system while reducing occupants' control over the internal climate of the building.

Procedure to Reduce Leakiness

In order to improve the integrity of the building envelope, the Office of Sustainability plans to install new, high efficiency windows, add ecologically friendly insulation to the walls and ceiling, and downsize the HVAC system. Taken together, these plans align with LEED best practices for improving Indoor Environmental Quality, Energy Efficiency and Source, and Material Efficiency and Effects within the house.

Windows were donated and installed by Capitol Window & Door in November 2013, exactly one year after occupancy by the Office. All of the windows provided were part of the Enterprise Eclipse series, are vinyl based, and at least double glazed. Five different models were used so that differences between the models, their effectiveness, and their cost could be highlighted and turned into educational materials. These windows were complemented by honeycomb blinds, which serve to further insulate by creating pockets of air between the windows and the room at large, which serve as a thermal buffer.

On April 7, 2014, Steve Clark of C & W Weatherization installed cellulose-based insulation in the walls and attic of the house. Cellulose was chosen for the high proportion of recycled materials and the comparably lower levels of toxicity of additives to the product (in this case, boric acid which serves as a flame retardant). Additionally, all windows, door frames and other cracks will be caulked and foam insulation will be applied around the foundation in the basement.

Data

The Office of Sustainability commissioned WKU Engineering students, led by Engineering faculty member Robert Choate and Steve Clark of C&W Weatherization to perform a blower door test (a way to evaluate the overall airtightness of a building) and to take thermograms (thermal images that can aid in identifying areas of air infiltration, found in Appendix A) of the house to assess the integrity of the building envelope. The results of these tests gave us a CFM50 (the airflow in cubic feet per minute needed to create a change in building pressure of 50 Pascals) of 6,532 cfm ±0.6%. Comparisons provided by Mr. Choate were that a modern home built to strict standards would produce a CFM50 of 600-1,000, while a two-story Victorian home would produce a CFM50 of 4,000-8,000. This demonstrates that the Office of Sustainability is significantly less airtight than most other homes to which it could be compared.

The results of the March 1 baseline blower door tests are found in Figures 3.1 and 3.2. Of importance is that the blower door apparatus was not capable of actually creating a negative pressure of 50 Pascals, which both demonstrates the extreme degree of leakiness in the home and necessitates that the data be extrapolated outwards to estimate a CFM50 value. As previously stated, a house built to modern, high-end standards would have a CFM50 value of approximately one tenth what was found in this building. Follow-up blower door tests were completed after the new windows were installed and more are planned for when the insulation has been blown in.

Date of Test: 3/1/2013		Technician:	
Test File: blowerdoorWsunroom		Project Number:	Sustainability House
Customer:		Building Address:	

Test Results at 50 Pascals:	
cfm50 Airflow	6532 (+/- 0.6 %)
ACH50	
Leakage Areas:	735.8 in² (+/- 1.1 %) Canadian EqLA @ 10 Pa 411.8 in² (+/- 2.0 %) LBL ELA @ 4 Pa
Building Leakage Curve:	Flow Coefficient (C) = 635.3 (+/- 3.3 %) Exponent (n) = 0.596 (+/- 0.010) Correlation Coefficient = 0.99920
Test Standard:	CGSB
Test Mode:	Depressurization

Figure 3.1, Results of Blower Door Test for House with Sunroom. Source: Robert E. Choate. (2013). "Energy Audit Baseline Study".

Date of Test: 3/1/2013		Technician:	
Test File: blowerdoorWoutsunrm		Project Number:	Sustainability House
Customer:		Building Address:	

Test Results at 50 Pascals:	
cfm50 Airflow	4755 (+/- 0.6 %)
ACH50	
Leakage Areas:	527.9 in² (+/- 1.4 %) Canadian EqLA @ 10 Pa 293.0 in² (+/- 2.5 %) LBL ELA @ 4 Pa
Building Leakage Curve:	Flow Coefficient (C) = 446.4 (+/- 4.1 %) Exponent (n) = 0.605 (+/- 0.012) Correlation Coefficient = 0.99890
Test Standard:	CGSB
Test Mode:	Depressurization

Figure 3.2, Results of Blower Door Test for House without Sunroom. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

Another significant insight was that the sunroom accounted for 27% of the house's total air leakage. The sunroom is uninsulated and has open space above, below, and to each side of it. This, along with the windows that line the room, leads to a very high transfer of heat and air throughout the room, which can then spread throughout the remainder of the house. This provides an opportunity to significantly reduce the air leakage by properly sealing the area between the house proper's envelope and the sunroom addition.

Figure 3.3, Photo of Sunroom

These results demonstrate that the Office should more tightly seal its building envelope to ensure optimal control over its thermal environment, allow for the downsizing of its HVAC system, and reduce its consumption of natural gas for heating.

Lifecycle Analysis of Windows

Windows can be a very energy intensive product to make. The high temperatures needed to smelt glass (up to 1500° C), along with the chemical treatments that further insulate and filter out UV light can release large amounts of CO_2 and other greenhouse gases into the environment (Pinkington, 1969). That said, window upgrades are a favorite project for individuals looking to reduce the energy load of a home, and demonstrably reduces the need to use air conditioning systems, lighting installations, and contributes to the indoor environmental quality of a home.

The windows used in the Office of Sustainability were vinyl-framed. This is neither the best nor worst material to use for window frames. Wood is generally superior, due to its high insulating capacity, rapidly renewable material source, low energy used in production (3,770 btus per pound), and recyclability. In contrast, aluminum frames are highly recyclable, but are non-renewable, are generally thermally conductive, and require massive amounts of energy to be produced (103,500 btus per pound). Vinyl is on par with wood for thermal insulation, which was the ultimate goal of this project, and only moderately energy-intensive (36,500 btus per pound), but is made from petroleum and therefore produce multiple pollutants during their production, and the recyclability of vinyl is generally debated. Despite vinyl producers insisting that vinyl windows are recyclable, a 1999 EPA report found that less than 0.6% of vinyl windows were diverted from landfills or incineration (Nadel, 2007).

The Office of Sustainability seeks to mitigate the rapid production of such materials by recycling materials until they are no longer viably usable by the general public. The windows that were removed from the home prior to upgrades were deemed unusable in future installations for their original intended use. Simply outdated, too leaky, and lacking many features that are valuable to regulating the thermal environment that are taken for granted in modern windows, these windows needed to first be repurposed before they could be recycled. To meet this end, the old windows were given to the coordinators of Project GROW (the group coordinating the community garden behind the Office) to be repurposed into cold frames.

The newly installed windows are expected to have a useful life of 10-15 years. Even after this period, these windows are expected to outperform the lowest-grade windows on the market, and may therefore be donated to other projects, like Habitat for Humanity, to extend their useful life.

CHAPTER 4

SOLAR ENERGY

In 2010, the buildings sector consumed 41% of the primary energy produced in the United States, beating the transportation and industrial sectors by 44% and 36% respectively (Buildings Energy Data Book, 2011). As the United States relies primarily on fossil fuels to produce its electricity, this attributes a significant portion of global climate change to buildings. Moreover, the search for and extraction of coal, oil, and natural gas have catastrophic effects on the environments from which they are removed. This takes shape as mountaintop removal in Appalachia, oil spills across the world, most notably and dramatically in the Gulf Coast, hydraulic fracturing and many other disturbances across the world. This chapter aims to contextualize the Office's energy use's place within this issue by describing the source of the Office's energy currently, the plans to install a solar energy apparatus to offset the Office's energy use, the projected data provided by Solar Energy Pioneers of Bowling Green, KY on how the solar apparatus will operate, and the overall environmental impacts of such a feature.

The current energy consumption at 503 Regents can be attributed mostly to the outdated appliances found around the house (including a refrigerator more than 20 years old), equipment necessary for the campus IT hookup (including a persistent server and three computers), and the equipment housed in the basement for use by bike mechanics working on Big Red Bikes. Generally sparse occupancy, compounded by generally responsible use of electronics by inhabitants help to reduce baseline consumption.

Definition of Problem: Reducing Energy Consumption

Peak Oil Theory dictates that once humans have extracted out all readily available oil, industries will adapt by shifting energy sources (Hubbert, 1956). This theory is frequently extrapolated outwards to include all fossil fuels. However, recent developments in Enhanced Oil Recovery techniques, including hydraulic fracturing (“fracking”) and tar sand extraction (which can consume more energy than is produced by the extracted product, and whose extraction releases 12% more greenhouse gases than conventional oil), force us to accept that instead of adapting their source, energy producers are content merely accepting the increased cost of extraction (Lattanzio, 2014). This is demonstrated by Lord Ron Oxburgh, former chairman of Shell, stating that "It is pretty clear that there is not much chance of finding any significant quantity of new cheap oil. Any new or unconventional oil is going to be expensive" (Wheatcroft, 2010). In light of our not being able to expect a transition to cleaner and renewable energy sources by the adaptation of major energy producers, the onus of responsibility for reducing the demand of fossil fuel energy falls on consumers. The possibility for reducing demand is strengthened by the fact that sustainable energy technologies are advancing. They are increasing their efficiency, reducing their cost of adoption and other barriers for use, and adapting the existing economic, political, and physical infrastructures.

The Office of Sustainability is receives its energy from Bowling Green Municipal Utilities, which in turn receives its energy from the Tennessee Valley Authority (TVA). In 2013, TVA produced 43% of its power through coal-powered plants, as well as 9% from natural gas or oil-fired plants (Tennessee Valley Authority, 2013). This is far superior to the national averages last released in 2011 of 82% Fossil Fuel, 8% Nuclear, and 9% Renewable energy (US Energy Information Association, 2011), but still poses significant environmental concerns with respect to global climate change and environmental pollution.

With a variety of renewable energy sources becoming increasingly efficient and affordable, it is generally inexcusable for a sustainability model home to power itself exclusively through conventional means. “Generate on-site renewable energy” is the first strategy for meeting energy demand with renewable energy listed in the LEED Core Concepts Guide. Since the TVA offers programs such as “Green Power Partners”, to encourage and subsidize green power production, this seemed to be a logical starting point for divesting the Office of fossil fuel consumption.

Procedures for Reducing Energy Consumptions

To counteract the consumption of fossil fuels for electricity, the Office of Sustainability will pursue two initiatives: 1) reduce the consumption of electricity by updating appliances to be more energy efficient, and 2) replace the fossil fuels that currently supply our electric energy with a solar source.

The first initiative is one that will progress slowly. There is currently no money budgeted to update appliances and electronics, meaning grants or other avenues of creative funding will need to be pursued. Additionally, best practices concerning the equipment used by bike mechanics are still being explored.

The second initiative, however, was put into action in spring of 2014. An apparatus consisting of an inverter (SMA America SB 5000) and solar panels (Sharp ND-250QCS) were installed above the sunroom on the south-facing side of the building by

Solar Energy Pioneers, of Bowling Green, Kentucky. This system is projected to produce ~7,000 kWh of electricity per year, offsetting ~66% of the office's baseline consumption, including more than 185% of the Office's consumption from March-June, when the solar gain is highest, as well as electricity use for air conditioning.

Data

Comparing the Office's utility bills to the EPA Household Carbon Footprint Calculator (Sept. 9, 2013 update) determined that in electricity consumption alone (10,500 kWh/year) contributes 14,332 pounds of carbon dioxide emissions per year. Using Solar Energy Pioneers' predictions for the house's grid energy consumption after the installation of the solar array (3,398 kWh/year), the Office will only contribute 4,635 pounds of carbon dioxide emissions per year, a reduction of 68% (the summary of Solar Energy Pioneers' audit can be found in Appendix B). The overall consumption of the house will decrease as new, high-efficiency appliances are installed, further reducing the carbon dioxide emissions that can be attributed to the Office.

The Office of Sustainability is subsidizing the cost of the solar panels and their installation by participation in various government sponsored programs. Notably, the Office is receiving the Federal Investment Tax Credit, which offsets 30% of the gross cost of the project ($6,292), as well as the KY Tax Credit for Renewable Energy Facilities ($1,000) and the Green Power Switch Generation Partners Incentive from the Tennessee Valley Authority ($1,000).

The gross cost of the installation of the solar apparatus amounts to $21,974. After credits, the cost at installation is $13,682, which will be paid for using funds from a TVA efficiency rebate the university received in 2011, leftover funds from a one-time grant from the Alliance to Save Energy, as well as with a subsidy from Solar Energy Pioneers themselves. Participation in Green Power Providers and the MACRS depreciation program will provide tax and stipend benefits to the Office for 10 and 5 years after installation, respectively. Moreover, the installation of this apparatus will significantly reduce the monthly energy bill of the office. Were these all factors that needed to be accounted for, the solar apparatus could be expected to return its investment in 5-years, and to continue to produce revenue for 20 years after that. Unfortunately, due to circumstances surrounding WKU's commercial building status and the general liability insurance required by Bowling Green Municipal Utilities, the array will end up costing more than it saves over its lifetime. This will be discussed in more depth in Chapter 7.

Lifecycle Analysis of Solar Panels

Recycling of solar panels is a process that is feasible, but currently not utilized to a great degree. The infrastructure for large scale recycling is not in place, and the process is often cost prohibitive—the value of materials reaped does not outscale the cost of recycling and the cost of diverting from a landfill. These projects are being actively worked on by industries and have seen many improvements since 2010. It is currently possible to reclaim 90% of the raw materials going into a solar apparatus, including the glass and conductive metals that make up the solar cell itself. By the end of the Office's solar apparatus's useful life around 2040, it is our hope that these industries will have advanced to the point of recycling solar panels being a seamless process without large infrastructural barriers.

This is not to discount the significant environmental benefits of the solar panels, however. Over its 25 year useful life, the solar panels can be expected to produce enough electricity to offset 122 tons of CO_2 emissions by partial divestment from fossil fuel-sourced electricity. This is a great amount, and could serve as qualification enough for the panels even if recycling were not a possibility, but given advancements in the field and commitments to improvement expressed by various solar and environmental organizations, the process for recycling solar panels will likely be greatly improved by the time the Office's panels are themselves recycled.

CHAPTER 5

LANDSCAPE MANAGEMENT

In light of growing worldwide population and demands on food and water, turf lawns are a resource intensive luxury that is becoming increasingly difficult to justify. In order to mitigate its own impact, the Office of Sustainability will transition from a predominantly turf backyard to one that is productive, resource efficient, ecologically viable and sustainable, and creates opportunities for education and student engagement. The yard will begin to serve multiple purposes: as a community garden, its layout will address pre-existing environmental concerns; as a case study on water management in karst landscapes; and as a space for student research projects, art installations, and group meetings. This chapter will discuss the environmental difficulties present within the space, describe the actions being taken to repurpose it to manage water more efficiently and to create an edible landscape, detail the various installations in place already, and assess the sustainability of the project overall.

Definition of Problem: Too much Lawn & Poor Drainage in Backyard

As it stands now, our yard is a 33m x 36m grass lawn with an injection well near the rear. This yard has numerous problems with rainwater drainage and frequently floods during periods of heavy rainfall. Moreover, lawn care is costly and requires the consumption of fossil fuels, chemicals and manpower that produce minimal returns for their costs.

The lawn could be rationalized as being for meeting or recreational space, but frequent flooding makes the space an unattractive option even for those ends. The low degree of use for the space also hampers the Office of Sustainability's stated goal of fostering student engagement and research. To make the space both more productive and attractive for use, the flooding must be managed.

<u>Procedure for Repurposing the Backyard</u>

Broadly, LEED Core Concepts approach stormwater management by maximizing pervious surfaces, redirecting stormwater to landscape features to retain water, and incorporating site design elements that hold water while serving other purposes.

Several projects are planned to address these concerns. All projects in some capacity seek to reduce the amount of lawn area dedicated to grass, thus reducing the amount of maintenance work necessary for mere aesthetics/upkeep, and to positively manage water runoff to the injection well. Currently, these include the addition of raised beds for gardening, a rain garden around the injection well (the installation used commonly in karst landscapes to drain rainwater that was installed in the backyard prior to the Office of Sustainability acquiring the house), and alternative paving methods for the driveway.

In order to manage the large influx of water from each rain, introduced water needs to have its movement slowed to a degree small enough to be handled by the natural drainage systems. Plans to slow the rainwater include a rain garden, water loving plants, trees, and shrubs to be installed from the area of greatest water inflow to the injection well which handles water drainage in the yard. This will improve the quality of water entering the groundwater systems below by slowing water’s movement through the yard, allowing for natural filtration of harmful components from the water and for greater absorption of stormwater by the ground, which will reduce the strain on the injection well.

Another practical concern that needs to be addressed is the lack of a complete loop for the driveway around the house. This needs to be remedied, but conventional methods would significantly increase the impermeable hardscape in the back yard, negatively affecting stormwater management systems. To counteract this, alternative materials for pavement are being explored. Currently, the loop has been completed with flat stones and gravel contained by a brick lining. This does allow for the infiltration of water, but is not the best possible alternative. For the purposes of demonstration, the possibility of re-paving the driveway with green pavers, which allow for grass to grow in between spacers that make up the driveway, is being explored.

Project Grow, the organization in charge of managing the community garden beds and shed, will make conscious efforts to ensure that any changes made to the backyard on their behalf mitigate instead of exacerbate existing drainage issues.

Additions of raised beds for the community garden will similarly hold and regulate the release of water, while the gardening shed, which if built conventionally would increase the area of impermeable hardscape of the yard, will instead be built with a green roof to assist in negating the added impermeable surface area this addition could yield. Additionally, this shed will be constructed out of shipping pallets and some of the original windows removed from the Office to reduce the consumption of new materials as much as possible.

The addition of gardening space into the yard could also potentially introduce unwanted materials--in the form of pesticides, fertilizers, treated water, and organic waste—if the plans do not take these concerns into explicit consideration. In order to ensure that no damaging contaminants enter the ecosystem because of the addition of this gardening space, several measures have been taken, including a clause in Project Grow's Memorandum of Agreement (Appendix C)between the WKU Landscape Architect, Building Architect, Sustainability Coordinator, University President, Community Garden Coordinator, WKU Americans for Informed Democracy representative, Ecology Club representative, Horticulture Club Representative and WKU Architect that requires organic methods be used, on-site composting to dispose of organic waste and to create fertilized soil for growing. In accordance with the Memorandum of Agreement, no chemical pesticides will be used and water will be taken and water for the plants will come from rainwater cisterns instead of from BGMU supplied treated water, so as to prevent fluoride and other treated materials from infiltrating the garden and local water systems.

One of the primary goals of the project is to improve the environmental quality of the yard and to positively impact the site and community. Environmentally, the gardening space will provide new habitat for various organisms, increase the amount of foliage which photosynthesizes and filters air, and create food sources for both humans and various fauna, including bees donated by the WKU Beekeeping Club. Proper cycling of crops will also encourage healthy soil for other organisms to use to their benefit. Increased root density in the topsoil will slow water and soil from reaching the injection well, as well as absorb a significant amount of groundwater for themselves.

<u>Data</u>

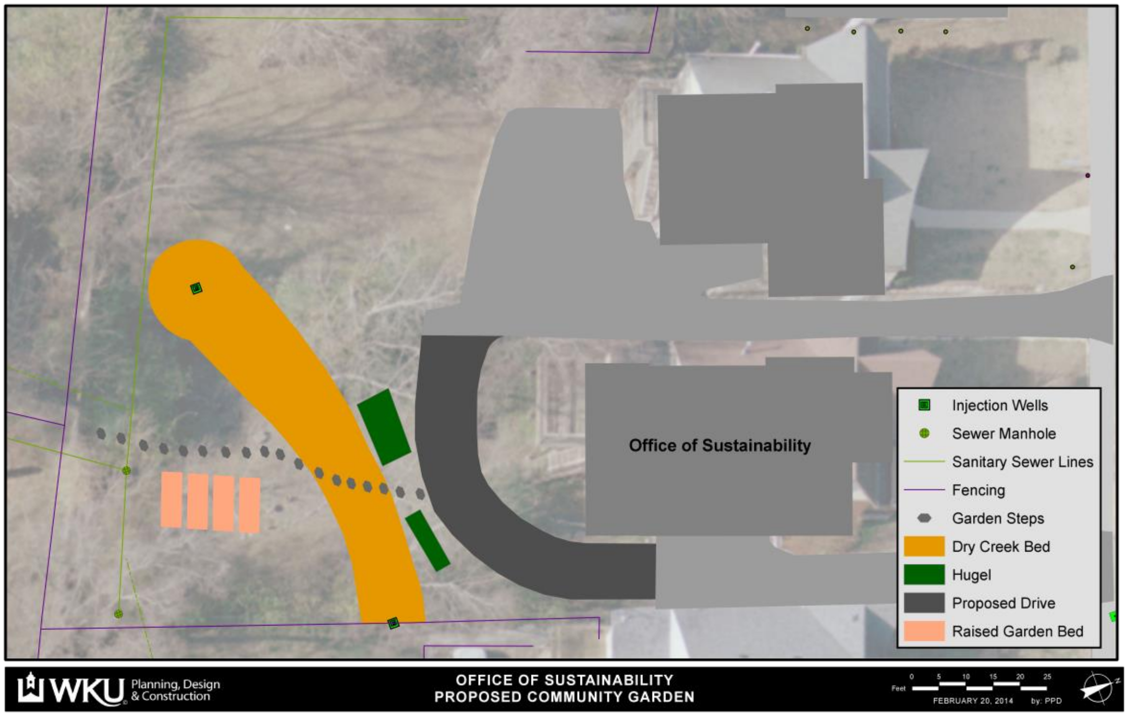


Figure 5.1, Plans for Repurposing the Office Back Yard.

The Office's current backyard has many issues with drainage and flooding. A stormwater reservoir that collects water from Regents Ave. exists on the east side of the yard (the green diamond closest to the bottom of Figure 5.1) that overflows after even moderate rainfall. This overflow follows the yellow highlighted area on Figure 5.1 to the injection well (a drilled vertical shaft designed to allow water to quickly penetrate the permeable ground layers underneath bedrock). This well quickly overflows, flooding the backyard, making it unattractive for growing plants or gathering people. Plans to mitigate this drainage all focus on slowing the movement of water from the reservoir to the injection well to a degree that the well can handle without overflowing.

Figure 5.2, Digital Model of Pallet Shed with Living Roof and Wall

The shed designed by Dr. Neal Downing with his Architecture and Manufacturing classes will house all of the equipment needed to maintain the community garden and yard. It is designed with a green roof and walls so that it will collect and consume rainwater instead of letting it slide off and into the yard.

Figure 5.3, Gravel- and Stone-paved Driveway.

This driveway, an intermediate solution to the parking issues presented by the yard, uses packed earth and gravel to collect and slow the movement of water to the injection well. Future plans exist to replace the packed earth with grass pavers to further increase its capacity to slow and consume water.

Figure 5.4, Back Yard Leading to Injection Well

The injection well, pictured here, sits at the lowest point of the yard. Notice how the fences in the background demonstrate the slope of the ground.

Figure 5.5, Raised Beds for Community Garden

These raised beds will hold water during rainfall, and when planted, will absorb some rainwater, completely removing it from the system flowing towards the injection well.

Lifecycle Analysis of Repurposing the Backyard

Plans to improve the rainwater management of the lawn using natural methods will ultimately improve the condition of the lawn with only occasional maintenance, and to turn the yard into an edible landscape and community gathering space. This provides more environmental benefits than noninterference would with only minor interference in the form of rocks and gravel imported from other WKU properties. Transportation is the only foreseeable negative environmental factor, and the overall distance traveled is negligible compared to the distance other commercial goods travel on average.

With the implementation of composting and regular use of collected rainwater for hydrating soil and plants, the gardening component of the yard will be almost entirely self-sustaining. Furthermore, these practices, along with the requirement that all plants be raised organically and therefore not introduced to artificial pesticides or fertilizers, ensure that no ecologically dangerous materials are introduced to the injection well, safeguarding the health of the water supply underneath.

Other projects, such as the green roof for the tool shed and the addition of fruit trees, are suspected to have minimal negative environmental impacts over the course of their lives, providing they are cared for and do not require replacements.

All materials used in the construction of the shed and raised beds is organic and can be returned to the ecosystem at disposal. Rotted wood that needed to be replaced can be used to harvest mushrooms in the darker, damper parts of the yard, an initiative under consideration by Project GROW.

CHAPTER 6

COLLABORATION AND ENGAGEMENT

In line with the Office of Sustainability's goal of "encourag[ing] cross-campus collaboration and partnerships, bridging academics and operations using the campus as a living laboratory where ideas can be practically implemented," the Office has been used as a focal point for students, campus, and community members to engage and pursue their interests within the field of sustainability. For some students these interests are academic, for others they are political, and for many, they are both. For campus officials, the motivation is most often financial—in line with the concept of the Triple Bottom Line, sustainability often translates into lowered operating costs for the university. Community members often provide a service for the university or office, but generally have an interest in sustainability for their own reasons and are happy to help out the Office of Sustainability in whatever ways they can. This chapter seeks to highlight the projects created and led by students at 503 Regents, the university entities who supported them, and the community members who assisted in renovating 503 into a model home of sustainability.

STUDENT INVOLVEMENT

Organization	Engagement with the Office
WKU Food Pantry	Housed within the Office, distributes food from community garden and farmer's market.
Elizabeth McGrew, MA in Social Responsibility & Sustainable Communities (SRSC)	Founded Project GROW, coordinated plans for community garden for graduate project. Presently Office of Sustainability Graduate Assistant, responsible for research and data collection for bi-annual AASHE STARS reporting.
Project GROW	Coalition of student groups, classes and individuals - Oversees all projects in the back yard/community garden.
Mechanical Engineering Topics with Prof. Robert Choate	Conducted blower door tests to establish baseline airtightness and used thermographic imagine to identify leaks.
Natural Resource Management with Dr. John All	Provided plans for site design.
Environmental Planning with Dr. John All	Provided plans for site design and stormwater management.
Construction and Materials with Dr. Neal Downing	Community Garden shed with green roof and repurposed building materials.
Ecology Club	Installation of shed's green roof.
WKU Americans for Informed Democracy (AID)	Installation of shed's living walls.
Structures Art Club	Installations in the back yard.
WKU GreenToppers	Recycling windows into cold frames for seed germination.
Horticulture Club	Composting, wildflower plot.
Big Red Beekeepers – WKU Agriculture Department	Beekeeping in the back yard.
Big Red Bikes	Operates out of the Office, mechanic shop housed in basement.
Mary Boothe	Completing an Honors Thesis about student awareness of Office of Sustainability initiatives.

Figure 6.1, Student Engagement with the Office of Sustainability

WKU Food Pantry

The WKU Food Pantry, founded by Social Work graduate student Sarah Arnold and formerly housed in the Gender and Women's Studies building, has moved to the Office of Sustainability to take advantage of a larger space and greater visibility. As part of their partnership with the Office of Sustainability, the Food Pantry will begin providing fresh food from the community garden to WKU community members that visit the space. This provides opportunities for future research on the effects of availability and cost on WKU community members' decision-making with respect to fresh versus packaged foods.

Project GROW

Project GROW, spearheaded by SRSC graduate student Beth McGrew, has grown out of a coalition of many different organizations to create a community garden and sustainable landscape in the back yard of the Office of Sustainability. Project GROW brought together and enabled many of the other projects found in Figure 6.1, including those completed by WKU AID, GreenToppers, Horticulture Club, Ecology Club, and the Big Red Beekeepers. The success of the community garden to this point can largely be attributed to Project GROW and Beth McGrew.

Mechanical Engineering Topics with Prof. Robert Choate

As discussed in Chapter 3, Prof. Choate's Mechanical Engineering classes have performed blower door tests with C & W Weatherization to support the Office's goal of tightening their building envelope a total of four times, the first time with thermographic imaging tests to identify major leakage points (these thermographs are found in Appendix A). These projects have provided the Office with data that could not have been acquired elsewhere. The hands-on experience gained in these is also invaluable to the students, and furthers the Office's goal of being a living laboratory and place for active experimentation.

Interpretive Signage

In order to complement the goals of the Office to connect with and educate members of the campus community about sustainability initiatives, I drafted interpretive signage detailing the aspects of the three major projects occurring 503. These signs were placed around the Office itself, using only short infographic blurbs designed to be quickly consumed and interesting to read. They serve to educate the visitors that come as a result of increased activity (AID meetings, the Community Garden, and Food Pantry, among others), to encourage involvement in the various initiatives of the Office, and to demonstrate the great capacity of the Office for facilitating similar projects—particularly by student researchers or community members interested in supporting the Office's mission.

The "Hole in the Wall" was the first of such signs to be made. It was designed after the first blower door test conducted by Prof. Robert Choate's Mechanical Engineering class to communicate the baseline information gained, and placed in the sunroom of the Office, opposite the windows that were the source of most of the leakage the sign discussed. Understanding what a CFM50 value is and what it translates to requires highly specialized knowledge, and to anyone outside of the weatherization industry, a chart of values would be meaningless. The effects of a hole in the wall in the context of space heating is easily understood, however. The hole is the exact size of sites of air leakage across the house aggregated into one space, according to the results of the

Figure 6.2, Hole in the Wall Sign Hung in the Office of Sustainability Sunroom

blower door test, and communicates the importance of proper insulation and improving the integrity of the building envelope.

This sign can be updated to reflect changes made in between the initial blower door test and follow-up tests to track the improvements made. Since the original blower door test, windows have been replaced, another blower door test administered to track the improvements from the windows alone, weatherization (insulation, caulking, foam) has been added, and a final blower door test was administered to demonstrate the aggregate effects of all changes made. Potentially, one or multiple signs could be drafted to detail the process and the improvements made at each stage. If this sign was to be redrafted at a later date, one improvement that could be made is to include language within the poster itself indicating that this information was gained from a student-led project, to further disseminate the message that student research in or about the building is encouraged.

Plans for future signs to be made include signs about the best practices demonstrated by grass paved driveways with respect to stormwater runoff management and the inverse relationship between the energy produced by the solar panel array and the building's carbon footprint. These will be drafted upon the completion of the project each sign references, then designed and printed by ImageWest, an on-campus advertising and public-relations company.

UNIVERSITY ENTITIES

By virtue of its mission and its place in the university administrative structure, the Office of Sustainability is reliant on many different entities within the university and community to pursue its goals and mission. This chapter seeks to explore the different ways that university and community entities have contributed to the Office of Sustainability, specifically the work on 503 Regents, in order to identify patterns that may prove beneficial to future comparable projects, both at WKU and at other institutions.

Office, Individual, or Department	Method of Contribution
John Osborne, Vice President of Campus Operations and Facilities	Pays half of 503 Regents rent, sponsored IT installation, purchased sign for front lawn, provides Office's annual operating budget, approval of all Office operations.
Joshua Twardowski, Manager of Campus Services, Department of Facilities Management	Provided herb garden for front lawn, completed driveway through back yard, provides advisement on landscaping.
Dale Dyer, LEED AP, Plant Operations Manager, Department of Facilities Management	Cooperated in assembling the energy and smart meter intertie to ensure specific data could be recorded.
Dan Chaney, LEED AP, Project Manager Department of Planning, Design, and Construction	Cooperated with and approved all property renovations to ensure compliance with university policies.
Helen Siewers, Landscape Architect, Department of Planning, Design and Construction	Provides advise on landscape design and planning, prepared backyard landscape plan.
Office of Research	Pays half of 503 Regents rent, purchased smart meter for electric data gathering.
Office of the President	Provided one-time funding support, endorsed, and cooperates with Project Grow on Presidents Garden plot.
Environment, Health, and Safety	Performed radon and mold testing without charge.
Department of Information Technology	Sponsored part of IT installation.

Figure 6.3, University Contributions to 503 Regents.

Vice President of Campus Operations and Facilities

Mr. John Osborne's support was essential to the success of 503 Regents He was one of the people who made it possible to have the house by voicing his support for Ryan's proposal that the Office acquire the house., He has continued his support of the project by providing the upkeep for the house in light of the Office's own insufficient operating budget. This includes all of the services necessary to integrate the building into campus infrastructure, like IT and signage, as well as custodial services, utility charges, and pays half of the Office's monthly rent.

Mr. Osborne's support has also ensured the cooperation of the Departments of Facilities Management and Planning, Design, and Construction in the work surrounding 503 Regents, including the landscaping services and the completion of the driveway.

The Office of Research

Dr. Gordon Baylis, Vice President of Research, strongly endorsed the use of 503 Regents as a living laboratory to encourage student research. His interest was similarly influential in getting the space allocated to the Office of Sustainability, and the Office of Research pays the half of the monthly rent not covered by John Osborne to keep the space. In addition, Dr. Baylis has taken interest in the house as a research project itself, and purchased the smart energy meter that allows for detailed reading of the house's energy use.

COMMUNITY INVOLVEMENT

Community Group or Business	**Method of Contribution**
Capitol Window and Door	Donated windows to the house.
C & W Weatherization	Insulated the house at cost, assisted Prof. Choate's class in weatherization tests
Bowling Green Blinds	Provided honeycomb blinds at material cost.
Solar Energy Pioneers	Installed solar array at material cost, assisted in paperwork for TVA Green Power Partners program.
Alliance to Save Energy	Provided $9,000 of grant funds for solar energy.

Figure 6.4, Community Sponsors of the Office of Sustainability

C & W Weatherization

Steve Clark of C & W Weatherization has offered his services free of charge to support the renovations of 503 Regents. As of April 10, 2014, Clark has performed four blower door tests on the house, assisted WKU Engineering students in performing their own tests, and has insulated the the house at material cost with ecologically responsible cellulose insulation.

Solar Energy Pioneers

Solar Energy Pioneers have demonstrated admirable dedication to ensuring the house solar array is as effective as possible. This includes providing the house with the newest panels possible, providing the array at material cost, and assisting hristian Ryan in navigating the quagmire of policies regarding the TVA Green Power Partners, BGMU grid intertie, and general liability insurance for the array. Solar Energy Pioneers understands the need for streamlining the process for switching to green power, and without their assistance with paperwork and policies, 503 Regents would not be solar powered.

CHAPER 7

INSTITUTIONAL BARRIERS TO SUSTAINABILITY AND INNOVATION

The Office of Sustainability seeks to use the space at 503 Regents to explore practical changes that can be applied to campus at large to improve environmental conditions and reduce the operating costs of the university as well as community homeowners. WKU has demonstrated significant commitment to sustainability in the past, but there are still great strides that can be made. Identifying innovative and sometimes nontraditional ways to meet the needs of the university while consuming and impacting the environment less is essential to changing the campus and community culture to promote health both for people and spaces. To do this, however, the Office must often act in ways that run counter to the general behaviors expected of university entities.

The Office of Sustainability's proposed renovations often greatly diverge from the university's standard operating procedures and have therefore encountered numerous infrastructural and procedural barriers to their implementation. If these practices are to be implemented elsewhere or scaled up in any way, these institutional barriers must be removed to encourage sustainable development. As they stand now, the extra work necessary to override established standard operating procedures in favor of more sustainable ones actively dissuades all but the most engaged and dedicated.

Solar Array and Indemnification Insurance

The Office of Sustainability's commitment to improving sustainable practices and experimenting with standard operating procedures occasionally placed the Office in completely uncharted administrative territory. Bowling Green Municipal Utilities (BGMU), our energy provider and a distributor of the Tennessee Valley Authority, requires an indemnification insurance policy to connect private solar panels to the central utility grid. For the Office of Sustainability's 5.5kW solar array, a minimum $500,000 policy is required. This policy was crafted with non-commercial entities in mind, as the commercial-level policy for this amount costs ~$1,600 per year—$500 more than the sum of all energy bills from the baseline year, even though the array will only cover 66% of the Office's energy demands. With this in mind, the insurance on the solar array alone costs $900 more than the energy saved by the array itself, and is coming directly out of the Office's already insufficient operating budget. The cost of insurance is significantly lower for residential policies, which bodes well for individuals looking for a private solar array in the BGMU service area. Despite 503 Regents being built as a residence, the fact that it is owned by WKU disqualifies it from residential-grade insurance.

Further complicating the adoption of solar energy on campus is the policy of state entities to not engage in indemnification or insurance contracts. Ryan and the University Attorney were able to establish an exception within university policy for 503 Regents after great debate. That work-around is not a permanent solution since the policy's existence is a concrete institutional barrier preventing university-wide divestment of TVA-supplied energy (wholly or partially) in favor of sustainable sources. The incompatibility of policies between two governmental institutions, WKU and TVA, compounded by the cost-prohibitive nature of commercial-level indemnification insurance policies, is damning to solar energy's potential to be widely adopted at the university level. Given the amount of energy consumed by universities (WKU consumed 56 million kWh from July 2012-June 2013, see Figure 7.1) these policy incompatibilities, which actively discourage divestment from conventional energy sources, ensure that universities remain great contributors to carbon emissions by fuel consumption.

Total Campus Electricity : Monthly Cost Consumption Stationary by Facility

Commodity Group / Commodity / Facility			WKU Substations		
			Consumption	Cost	Cost / Consumption
Electricity/Steam in kWh	Electricity	Jul-2012	5,697,560	545,652	0.0958
		Aug-2012	5,797,206	565,396	0.0975
		Sep-2012	5,561,268	560,447	0.1008
		Oct-2012	4,953,135	352,963	0.0713
		Nov-2012	4,236,986	311,660	0.0736
		Dec-2012	3,674,500	337,598	0.0919
		Jan-2013	4,340,327	359,364	0.0828
		Feb-2013	4,241,035	339,485	0.0800
		Mar-2013	4,407,434	337,252	0.0765
		Apr-2013	4,574,166	322,898	0.0706
		May-2013	4,366,400	317,148	0.0726
		Jun-2013	4,555,690	460,665	0.1011
	Total		**56,405,707**	**4,810,529**	**0.0853**

Figure 7.1, Campus Annual Energy Use, Source: Panoptix® Dashboard by Johnson Controls

Limiting Factors of the Office

There are many limitations within which the Office of Sustainability must operate. Those that will be discussed here are the understaffing of the Office and the absence of discretionary funds for the Office to use.

The first limiting factor to be considered for the progress of the house's renovations is the understaffed nature of the Office of Sustainability itself. Ryan is the only staff member of the Office of Sustainability and in her position handles dozens of responsibilities and projects.

Home renovation is a laborious and time-consuming task when done by private homeowners who communicate directly with those providing renovation materials and services. Ryan must juggle: researching best practices for every aspect of the remodel of 503 Regents; communicating her findings with the administration: acquiring funding for every project; receiving approval to diverge from standard university operating policies to explore alternative procedures; communicating the results of the projects at 503 Regents to the multiple stakeholders; all while paying active attention to her responsibilities outside 530 Regents. Currently student researchers are driving which potential projects are put into action at 503 Regents. In order to ensure the most sustainable alternative for each individual renovation is understood and pursued, it would be recommended that a graduate assistant or part-time staff, dedicated to research on potential projects and practices, be introduced as part of the endeavor. It was Ryan and student researchers' experience that there is much conflicting information how comparably sustainable renovation options are, and that finding a conclusive answer is time- and effort-intensive. This was the case for Ryan when she had to decide between fiberglass and cellulose insulation materials. Changes to the processes for both varieties' manufacture in recent years have shifted the relative benefits of each, making older documentation obsolete in some regards. Figuring out exactly what was still relevant and what was not took considerable time.

Additionally, the Office of Sustainability receives an insufficient annual operating budget to fund its work. While ultimately this may be a boon in fostering community and demonstrating the cost-effectiveness of many of the initiatives the Office puts out, this is a drain on the productivity of the Office that must be accounted for. Creative funding methods are time-consuming and finite. In order to produce results more quickly and to increase the capacity of the Office to explore innovative methods to promote sustainability, greater financial resources would need to be allocated to the Office to circumvent the difficulties of obtaining funding for each individual initiative.

Barriers in University Culture

Another barrier was that many departments, offices, and divisions at WKU felt that the Office of Sustainability's initiatives either ran counter to standard procedure and policy, or were not addressed within university policy at all. The entities attempted to deter practices at the Office that would require adaptation of those policies and procedures. Negotiating permission to proceed with each project was a drain on the productivity of the office and at times prevented a project from proceeding in its entirety.

To counteract the limiting effect of these restrictions, a greater effort needs to be made to communicate that the space at 503 Regents is one of innovation and experimentation that is to be held to a different standard than the campus writ large. Outright denial to cooperate on the part of different entities on campus bodes ill for innovation in general on campus. A culture shift in university staff and administration towards a greater emphasis on sustainability is necessary to encourage the exploration and adoption of newer and more effective methods of maintaining and operating the university. This complaint is one that is echoed in the earlier discussion of the Triple Bottom Line, in that cost and convenience are often prioritized over inclusive wellbeing and progress.

Certain things are denied to Ryan and the Office of Sustainability because they are simply impossible or the logistics of implementing them outweigh any benefits that could possibly reaped. Many detractions voiced to the Office, however, do not seem to be based in such concerns. Of note are those voiced by Grounds Maintenance and Campus Gardens about the planned features of the community garden, including compost, general clutter/mess, and the potential for the inclusion of animals within the garden, which are not concerns voiced out of impossibility but rather incompatibility. Not fitting the mold of previous grounds and gardening work on campus is to be expected, as community gardening is a novelty of itself on campus, and this must be understood and accounted for if the Office of Sustainability is to be able to achieve its mission and goals.

CHAPTER 8

CONCLUSION

The Office of Sustainability's involvement with 503 Regents has spanned two years at the point of this document's completion. Despite this, the renovations to the building are nowhere near their completion. Several important ideas need to be addressed in these closing remarks and this chapter seeks to address them all. In turn, this chapter will assess the relative hierarchy of concerns facing the project and building, the greatest successes of the project, avenues for further research, and my own experiences and growth due to working with the Office of Sustainability on this Capstone Thesis.

Hierarchy of Concerns

To assert that all of the concerns described are equal in compromising work towards sustainability would be fallacious. In the larger scheme of pursuing sustainable change, issues of policy and culture are both the most offensive and complex to solve.

By the EPA Carbon Footprint Calculator, WKU is responsible for 76 million pounds of carbon dioxide emissions per year in electricity consumption alone, but cannot possibly be expected to divest in favor of sustainable energy while BGMU and many other energy providers require commercial indemnification insurance policies for renewable energy arrays that cost more than the energy that is actually produced by the arrays. Further compounding this issue is that it is the general policy of state institutions to not purchase indemnification insurance for any reason. Ryan had to navigate overwhelming amounts of institutional red tape to intertie the Office's solar array to the power grid, and ultimately ended up costing the university money instead of saving them money by doing so. The capacity of WKU to reduce carbon emissions by investing in renewable energy is great, but so long as state, university, and corporate policies continue to actively discourage renewable energy investment, this capacity will never be met.

Similarly, so long as university staff and officials resist adaptation by mere virtue of not desiring change, WKU cannot begin to address its environmental impact. Means to communicate the importance of sustainability initiatives that resonate with the public will be necessary to convince the university community at large to begin prioritizing environmental sustainability over the effort necessary to change comparably small habits and procedures.

Successes of the Project

One of the biggest surprises to come from 503 Regents was Project Grow. Elizabeth McGrew started Project Grow as part of her Social Responsibility and Sustainable Communities project to create a campus community garden. Since its creation, Project Grow has managed to legitimize a practice on campus that is never even tangentially mentioned in WKU landscaping policies and managed to formalize every aspect of it along the way—from dedication of space, to the upkeep by and participation of student organizations. WKU has historically had chronic difficulty integrating students into policy and administrative decision-making, so successfully fostering cooperation between Landscape Management, the Office of Sustainability, and several student organizations through the Project Grow Memorandum of Agreement (Found in Appendix C) may serve as a model for other divisions of the university.

In terms of the renovations to the house itself, the weatherization project has been subject to enormous success. After windows and insulation, the CFM50 value which describes the airtightness of the building has been decreased by more than 40% from the baseline 6,532—which is on par with an older, larger, and uninsulated Victorian home. Moreover, student involvement has been a part of each step of the process, with Prof. Choate's Mechanical Engineering students performing blower door tests a total of four times, both providing them with valuable experience and the Office with useful and persuasive data with which to make the case for improved weatherization of all comparable buildings. These collaborations between the Office, students, and community members are part of what Christian Ryan originally pursued 503 Regents to make possible, and it is encouraging to see proof of concept and goal work so well so early.

Personal Reflections

One of the Office of Sustainability's primary functions is to foster student engagement, as this thesis has sought to demonstrate. It is perhaps not appropriate, then, to close without describing how the Office has impacted my education and experiences.

In the year following Ryan acquiring 503 Regents, vast amounts of planning went into what 503 Regents and my part in it were to look like. I lacked any formal education in construction or sustainability, so it was by pursuing LEED Green Associate status that I quickly gained the knowledge that Ryan and many of the university staff with which Ryan worked on 503 Regents already possessed. Green Associate accreditation required that I take one of the hardest tests I've encountered thus far, spanning green building concepts, case studies, LEED history, and US laws relating to building and construction standards. This prepared me well to learn from Ryan and those working with her, like Dan Chaney and Dale Dyer (discussed in Figure 6.3), all three of whom are LEED Associated Professionals—more advanced and specialized than a Green Associate—as well as to communicate what I learned to the general public. On top of enabling me to engage critically with this project, LEED Green Associate training helped connect my three fields of study—biology, political science, and social responsibility—by creating a context in which an understanding of all three was important.

WKU's premier status with the Association for the Advancement of Sustainability in Higher Education also allowed me to assist Ryan with presenting the WKU Green Tour to experts in sustainability in university environments from across the country. My role was to lead the tour during the portion related to 503 Regents and current campus sustainability initiatives. Doing so tested my knowledge of the space and the concepts the Office renovations have addressed within it, and not just the parts I had previously assumed to be most important. Unanticipated questions from tour participants helped inform the angles taken with analysis from then on, as part of the goal of this thesis is to be of use to those who wish to undergo similar projects in the future.

REFERENCES

Arnold, C. (2009, June 01). *Building envelope design guide - introduction*. Retrieved from http://www.wbdg.org/design/env_introduction.php

Elkington, J. (1998). *Cannibals with forks: The triple bottom line of 21st century business.* Capstone Publishing Ltd.

Etkins, R., & Epstein, E.S. (1982). The rise of mean sea level as an indication of climate change. *Science*, (215), 287-90.

Holland, G., & Bruyère, C. (2014). Recent intense hurricane response to global climate change. *Climate Dynamics*, *42*(3-4), 617-27.

Hubbert, M.K. (1956, March 7). Nuclear Energy and the Fossil Fuels, *Spring Meeting of the Southern District, American Petroleum Institute*.

Ibáñez, I., Primack, R., Miller-Rushing, A., Ellwood, E., Higuchi, H., Don Lee, S., Kobori, H., & Silander, J. (2010). Forecasting phenology under global warming. *Philosophical Transactions: Biological Sciences*, *365*(1555), 3247-60.

Lattanzio, R. (2014) Canadian oil sands: Life-cycle assessments of greenhouse gas emissions. *Congressional Research Service.*

Matulka, R. (2013, December 16). *Energy saver 101 infographic: Home heating*. Retrieved from http://energy.gov/articles/energy-saver-101-infographic-home-heating

Nadel, B. (2007, May). *Windows and sustainability: An environmental perspective*. Retrieved from http://continuingeducation.construction.com/article.php?L=20&C=211

Osborne, J. Western Kentucky University, Campus Services and Facilities. (2009). *Energy policy*. Retrieved from website: http://www.wku.edu/policies/csf_policies/energy_policy_90400.pdf

Pinkington, L. (1969). *Review lecture: The float glass process*. Royal society of london. series a, mathematical and physical sciences, London, England. doi: 10.1098/rspa.1969.0212

Roessig, J., Woodley, C., Cech, Jr., J., & Hansen, L. (2004). Effects of global climate change on marine and estuarine fishes and fisheries. *Reviews in Fish Biology and Fisheries*, (14), 251-75.

Rush, R. (1991). *The building systems integration handbook: The american institute of architects*. Architectural Press.

Sridhar, K., & Jones, G. (2013). The three fundamental criticisms of the triple bottom line approach: An empirical study to link sustainability reports in companies based in the asia-pacific region and tbl shortcomings. *Asian Journal of Business Ethics*, (2), 91-111. doi: 10.1007/s13520-012-0019-3

Stallings, R. (2013, January 06). [Web log message]. Retrieved from http://www.remodelersecotraining.com/what-is-corporate-social-responsibility-for-small-business/

Tennessee Valley Authority. (2013, September 30). Power supply from TVA-operated generation facilities. *Tennessee Valley Authority 10-K*, 12.

U.S. Environmental Protection Agency, Office of Research. (2013). *Life cycle assessment*. Retrieved from website: http://www.epa.gov/sustainability/analytics/life-cycle.htm

US Department of Agriculture Agricultural Marketing Service. (n.d.). *Food deserts*. Retrieved from apps.ams.usda.gov/fooddeserts/foodDeserts.aspx

US Department of Energy. (2012, March). Buildings share of US primary energy consumption (percent). *Buildings Energy Data Book 2011*, 1.1.3.

US Department of Energy. (2012, May 30). *Tips: Heating and cooling*. Retrieved from http://energy.gov/energysaver/articles/tips-heating-and-cooling

US Energy Information Association. (2012, September). Primary energy overview, Selected years, 1949-2011. *Annual Energy Review 2011*, 5.

Wheatcroft, P. (2010, February 11). The next crisis: Prepare for peak oil, *The Wall Street Journal.* Retrieved from: http://online.wsj.com/news/articles/SB10001424052748704140104575057260398292350

World Commission on Environment and Development. (1987). *Our common future*. Oxford, England: Oxford University Press

APPENDIX A

THERMOGRAPHIC IMAGES (BASELINE DATA SET)

Figure A.1. Cold Air Infiltration around Big Red Bike Office Window. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

Figure A.2. Cold Air Infiltration around Coordinator Office Window. Source: Robert E. Choate. (2013). "Energy Audit Baseline Study".

Figure A.3. Cold Air Infiltration around Foyer Windows. Source: Robert E. Choate. (2013). "Energy Audit Baseline Study".

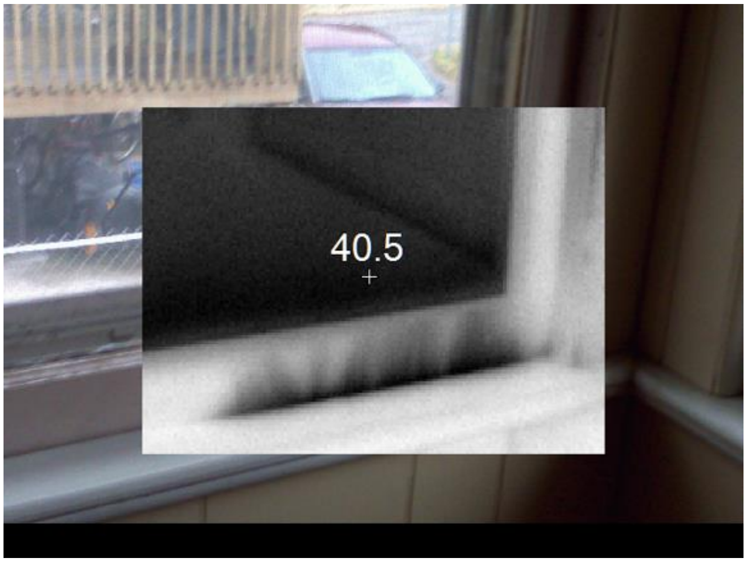


Figure A.4. Cold Air Infiltration and Warm Air Escape around Sunroom Window. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

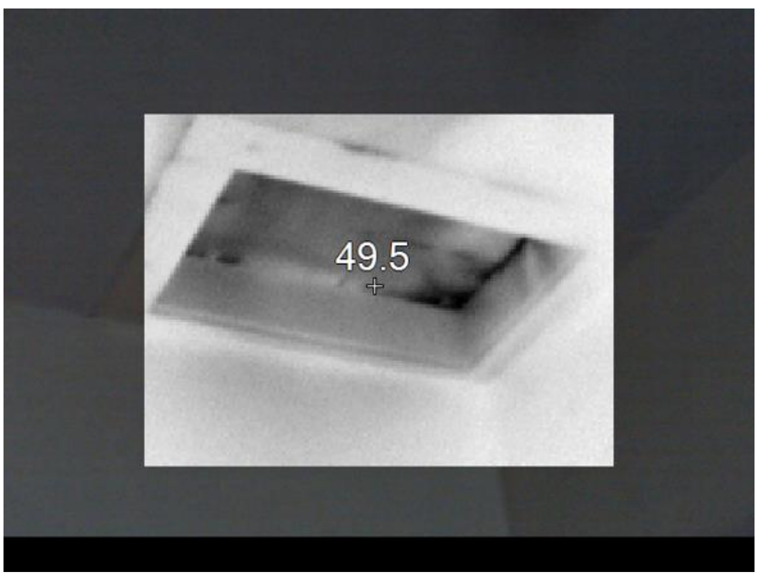


Figure A.5. Warm Air Escape through Attic Hatch. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

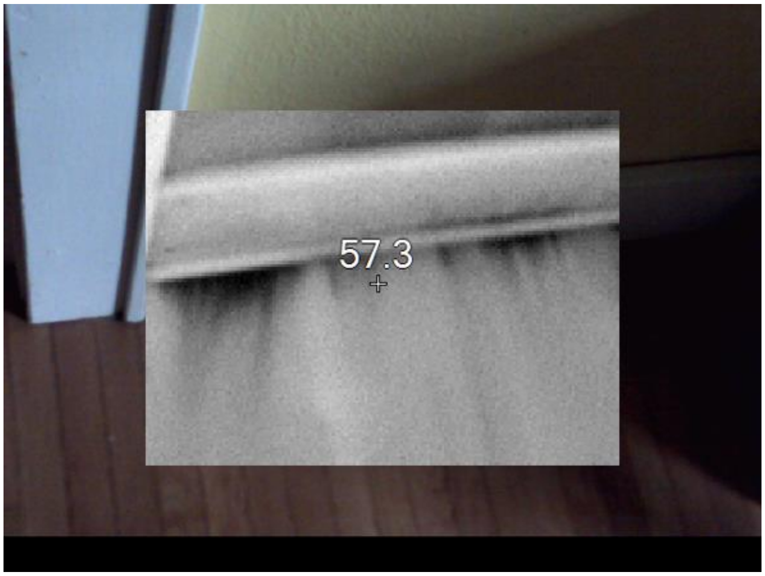


Figure A.6. Warm Air Escape through Kitchen Baseboards and Molding. Source: Robert E. Choate. (2013). "Energy Audit Baseline Study".

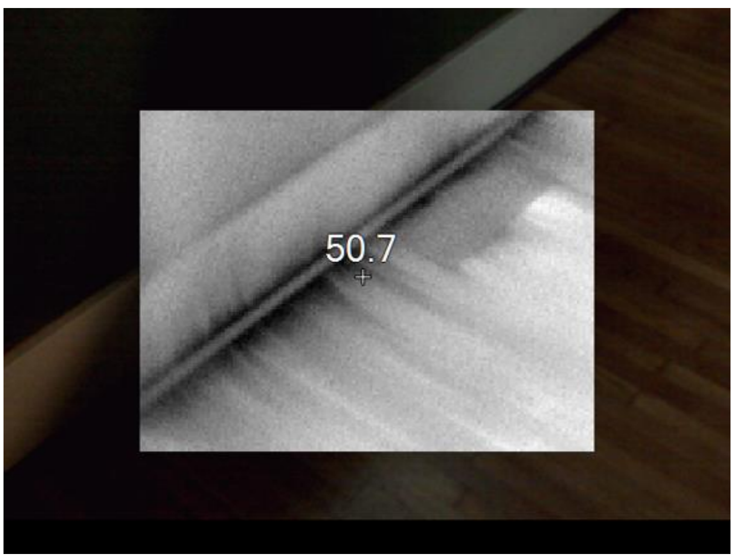


Figure A.7. Warm Air Escape around Coordinator Office Baseboards and Molding. Source: Robert E. Choate. (2013). "Energy Audit Baseline Study".

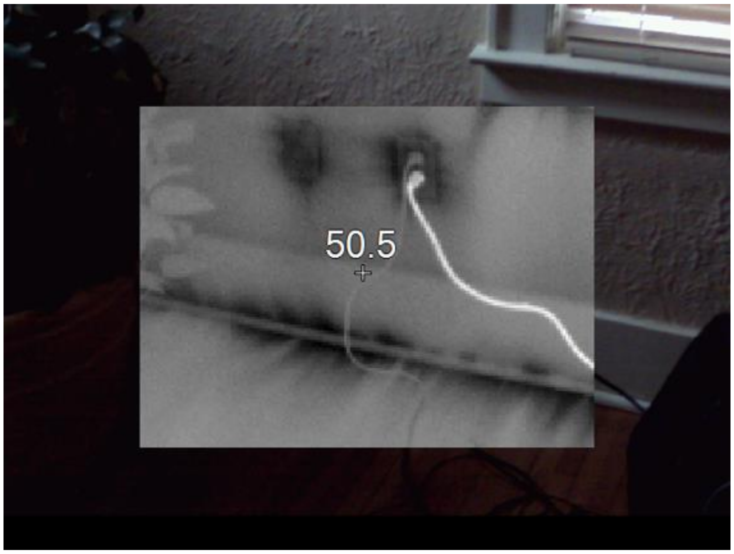


Figure A.8. Warm Air Escape around Foyer Baseboards, Molding, and Electrical Outlets. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

Figure A.9. Warm Air Escape around Kitchen Ventilation Installation. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

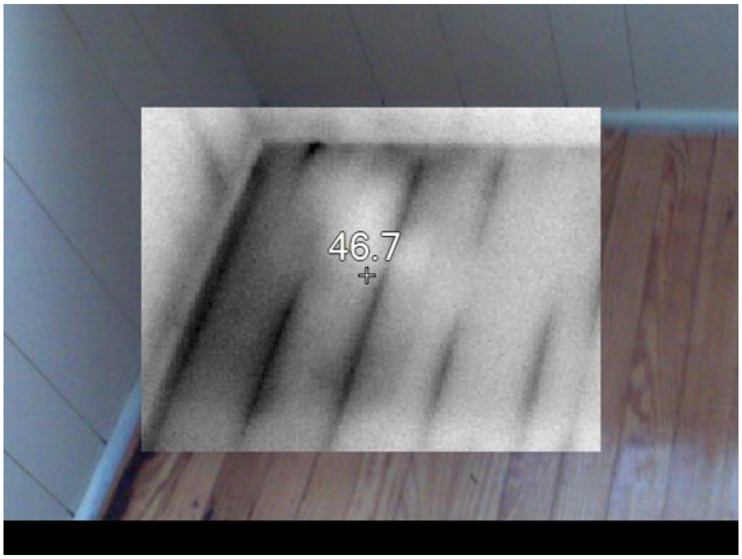


Figure A.10. Cold Air Infiltration around Sunroom Baseboards. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

Figure A.11. Cold Air Infiltration around Sunroom Ventilation Installation. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

Figure A.12. Warm Air Escape through Sunroom Ceiling. Source: Robert E. Choate. (2013). “Energy Audit Baseline Study”.

APPENDIX B

SOLAR ENERGY PIONEERS PROPOSAL

Proposal prepared for Christian Downing

Summary

Customer
Christian Downing
WKU
270-745-2508
christian.ryan-downing@wku.edu

Site Address
503 Regents
Bowling Green, KY 42101

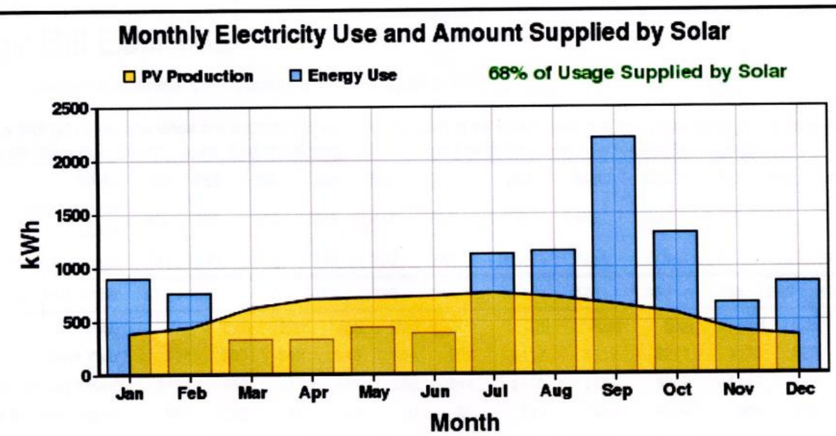
Mailing Address
503 Regents
Bowling Green, KY 42101

Company Contact
Tommy Jones
Partner
Solar Energy Pioneers
8141 Nashville Road
Bowling Green, KY 42101

25 Year Financial Analysis	
Utility Savings Over Initial Term	$20,188 $67 / mo (avg)
Payback Period	5-6 years
Total Life-Cycle Payback (Cash Flow compared to Net Cost)	219%
Rate of Return on Cash Invested	11.5%
Levelized Cost of Solar Energy	$0.085 / kWh

Cost Breakdown		
Gross System Cost	$21,042	($3.83/watt DC, $4.48/watt AC)
Sales Tax (6.00%)	$932	
Installer Contract Cost	$21,974	($4.00/watt DC, $4.68/watt AC)
TVA - Green Power Switch Generation Partners 1k Incentive	($1,000)	
Federal Tax Credit/Tax Impact	($7,292)	
Net Cost (year of installation)	$13,682	($2.49/watt DC, $2.91/watt AC)
MACRS Depreciation	($7,488)	
Green Power Providers 1-10	($6,747)	
Net Cost (all years)	($553)	(-$0.10/watt DC, -$0.12/watt AC)

System Description	
Total System Size	5.500 kW DC Power (STC) / 4.700 kW AC Power (CEC)
Estimated Annual Production	7,102 kWh
PV Panel Description	Qty. 22 - Sharp Model: ND-250QCS
Inverters	Qty. 1 - SMA America Model: SB5000US (240V)



Assumptions: Post-Solar Electric Rate Schedule for City of Bowling Green is BGMU (Rate Code: Copy of RER) Annual utility inflation: 5.50% (assumed). Energy Bill Savings are actual, without any tax effects applied.

Energy Bill Estimate

The following energy bill estimate is without any tax effects applied.

The **Energy Bill Savings** line does not include the opportunity cost of no longer being able to take energy bill expense deductions on corporate income taxes. See the Energy Bill Savings line in the cash flow for this tax impact.

(kWh)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Utility Usage without Solar	901	765	332	338	444	392	1,129	1,152	2,207	1,315	661	864	10.5k
Solar Production	390	443	622	710	720	736	762	724	648	577	401	368	7,102
Utility Usage with Solar	511	322	-290	-372	-276	-344	367	428	1,559	738	260	496	3,398

(Cost)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Last Year	$94	$80	$42	$45	$54	$52	$117	$119	$211	$130	$73	$93	$1,110
Utility Bill without Solar*	$101	$86	$37	$38	$50	$44	$126	$129	$247	$147	$74	$97	$1,176
Utility Bill with Solar*	$57	$36	$0	$0	$0	$0	$41	$48	$174	$83	$29	$56	$524
Annual Excess Credit	Credit for excess electricity generated (month of credit depends on interconnect date)											$135	$135
Utility Bill Savings	$44	$50	$37	$38	$50	$44	$85	$81	$73	$64	$45	$176	$787

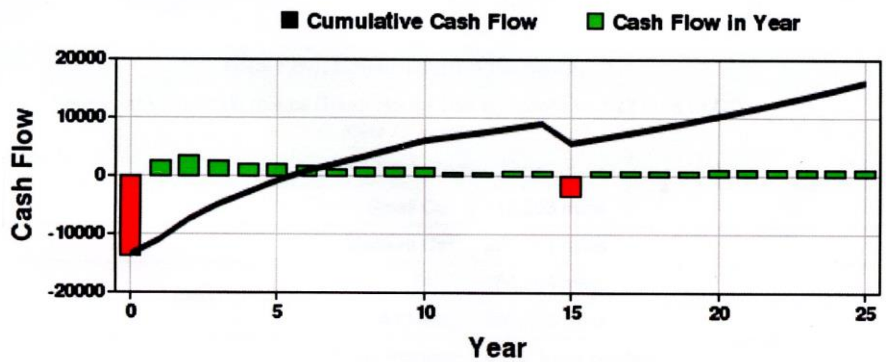
*Includes utility rate increase of 5.50%

NOTES ON **Annual Excess Credit** AND **Energy Bill Savings**:
The Energy Bill Savings is your Pre-solar Bill minus the Post-solar Bill, plus the Annual Excess Credit (Utility True-up). The energy "Credit for excess electricity generated" cannot be greater than the energy charges incurred during the year.

Proposal prepared for Christian Downing

Financial Analysis

The first chart summarizes the cash flow you can expect from the system quoted. Key financial measures are also provided.



Financial Summary	
Utility Savings Over Initial Term	$20,188
Average Monthly Utility Savings	$67 (over system life)
Net Cost (In year of installation)	$13,682
Payback Period	5-6 years
Rate of Return on Cash Invested	11.5%
Total Life-Cycle Payback (Cash flow compared to Net Cost)	219%
Levelized Cost of Solar Energy (Net Cost / lifetime energy production)	$0.085 / kWh

Environmental Impact Analysis

Your solar system will generate significant environmental benefits. These come primarily from avoided power plant emissions. Below is a summary of environmental benefits your solar system will provide.

Your New, Lower Carbon Footprint	
Your solar system will reduce Green House Gas emissions by **122 tons of CO2** (Over 25 years)	
Equivalent CO2 Reductions	
Small Car:	412,203 miles
Medium Car:	221,091 miles
SUV:	154,904 miles
Air Miles:	250,722 miles
Trees Planted:	4,864 trees planted
CO2 from Trash & Waste:	221 persons

APPENDIX C

PROJECT GROW MEMORANDUM OF AGREEMENT

Memorandum of Agreement

This memorandum of Agreement is made on February 4, 2014 by WKU Project Grow, WKU's Office of Sustainability, WKU Department of Facilities Management, WKU Ecology Club, WKU Horticulture Club, WKU Food Pantry, WKU President Gary Ransdell, and WKU Americans for an Informed Democracy for the purpose of achieving objectives related to WKU's Community Garden at 503 Regents Ave.

Purpose

Western Kentucky University is committed to sustainability and seeks to demonstrate this through educating WKU students and the community about various sustainable land-use practices as practiced in WKU's Community Garden located at the Office of Sustainability at 503 Regents Ave. As global population soars, land, water, and food are becoming increasingly precious resources. Using ones' home landscape as a means to provide oneself with food can reduce dependency on and demand for the unsustainable land-use practices that currently dominate the food market.

Further, the WKU Community Garden seeks to build community by bringing various organizations and individuals together around growing, harvesting, preparing, and eating food, as well as general sustainable care for the land.

Obligations of the Partners

The WKU Community Garden requires a partnership between the Department of Facilities Management, the Office of Sustainability, WKU Project Grow, WKU Ecology Club, WKU Horticulture Club, WKU Food Pantry, WKU President Gary Ransdell, and WKU AID. Respective representatives for these departments are Helen Siewers, WKU's Landscape Architect; Christian Ryan-Downing, WKU Sustainability Coordinator; Elizabeth McGrew, WKU Community Garden Coordinator, Project Grow representative, and Food Pantry Coordinator; Molly Kaviar, WKU AID; Adam Edge and Neal Downing, WKU Ecology Club and Building Sciences; Gary Ransdell, WKU President; and Corinn Sprigler, WKU Horticulture Club. The Partners acknowledge that no contractual relationship is created between them by this Memorandum but agree to work together in the true spirit of partnership to ensure the success of WKU's Community Garden.

Cooperation

a. All participating organizations and individuals will be responsible for their plot. This includes planting, watering, weeding, and harvesting.
b. WKU's Community Garden is committed to sustainable land-use practices, and therefore requires participating organizations to practice organic gardening methods so as to not disrupt the integrity of other plots seeking to practice organic methods.
c. Failure to maintain one's plot or to ensure its maintenance by a third party will result in repossession of the plot by Project Grow and possible redistribution to another organization or individual.
d. Project Grow will ensure the care of plots or space not maintained by other organizations or individuals. However, the Department of Facilities Management will provide lawn service to include weed eating and mowing.
e. All plots are granted to organizations or individuals for one calendar-year, from January through December. Some exceptions may apply, and all organizations and individuals in good standing with WKU's Community Garden may continue to renew their plot.
f. At the end of the one-year term, the plot must be prepared for the coming year by removing dead plants and debris, and repairing any harm done to structures throughout the previous year, i.e. damaged raised beds, roof structure, etc., if applicable.

Resources:

g. Project Grow agrees to provide training support for the maintenance of WKU's Community Garden.

a. Project Grow will manage an organic seed bank from which participating organizations and individuals can obtain seeds. This is to ensure all seeds and plants in WKU's Community Garden retain their organic integrity.

b. The Department of Facilities Management will provide soil for raised beds, woodland debris for hugel construction, and some soil amendments, if available.

c. The Office of Sustainability will supply water, though organizations and individuals will be responsible for watering their plots.

Signatures of project partners:

______________________	______________
Helen Siewers, WKU Landscape Architect	Date
______________________	______________
Christian Ryan-Downing, WKU Sustainability Coordinator	Date
______________________	______________
Gary Ransdell, WKU President	Date
______________________	______________
Elizabeth McGrew, WKU Community Garden Coordinator	Date
______________________	______________
Molly Kaviar, WKU AID Representative	Date
______________________	______________
Adam Edge, Ecology Club Representative	Date

Neal Downing, WKU Architect — Date

Corinn Sprigler, Horticulture Club Representative — Date