Super Green Residence Hall

ENVS: 4100 Appropriate Technology and Sustainability; Campus as a Living, Learning Laboratory

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II. Executive Summary

Western Michigan University includes sustainability in its mission statement and has consistently pursued many sustainability related projects. However, students do not have a viable option for sustainable living. This analysis will explore the current on campus living at Western Michigan University and provide insight on other universities sustainable residence halls.

After completing both the preliminary research and the case studies of four different university residence halls, each case study has led us to different insights about green buildings. The results of our case study on Ryan Hall at the University of Notre Dame proved that even though the hall was certified as LEED Gold, it was not any more efficient than the other non-certified halls on the campus. This building is a good example of how the LEED certification process is not effective enough at reducing GHG emissions and further initiatives need to be implemented to create a truly green residence hall. The second case study was on the Williams Village North Hall at the University of Colorado Boulder, this hall had similar results to the Ryan Hall case study, but revealed several new ideas. The Williams Village North Hall offers the opportunity for a large amount of students to live in a sustainable community, and also offers the experience of a small, sustainability focused, learning community. Even though Williams Village North has reduced its energy consumption by 30%, it is still consuming a large amount of energy and is still negatively impacting the environment. The third case study was on the Deep Green Residence Hall at Berea College; this hall was very different than the previous two case studies. Even though the building has not yet been constructed it will be LEED Platinum certified and is striving for the Living Building Challenge "Petal Recognition" in Site, Health, Materials, Equity and Beauty. It has worked to incorporate students, faculty, and the community into the design and construction in hopes of creating a greater education opportunity. The last case study was done on Warren Wilson College's Ecodorm, which improved enrollment and retention by providing an experience where students challenge themselves by limiting their environmental impact and develop sustainable behavior change. The living learning laboratory creates an atmosphere in the Ecodorm that helps improve environmental awareness, promote mindfulness, and teach people to be more community driven. Each of the case studies revealed a different conclusion about sustainable residence halls and leaves us to decide what the best option is for a sustainable hall on Western's campus.

After reviewing the best practice analysis of the four residence halls, we propose that WMU build a sustainable residence hall on campus to comply with its mission to incorporate sustainability into campus culture. We suggest that the building consist of about 150-200 beds. One of the most important aspects of the process will be the planning. The student population should be heavily involved in the planning process in order to make sure their voices are heard as well as it being an educational experience. We saw examples of this done at Berea College as well as Warren Wilson which both have residence halls that push the limits on sustainability.

Our vision for WMU's sustainable residence hall should be a net zero carbon building that incorporates the newest cutting edge sustainable design technology. The building will reach carbon neutrality through the utilization of renewable infrastructure such as PV arrays, geothermal energy, and wind power. The residence hall must be built with a tight building envelope with the use of structurally insulated panels. During an interview with Stan Cross from Warren Wilson, he said that this aspect of the building process is absolutely crucial. All materials used throughout the construction should come from local sources. This will help reduce the carbon footprint during the construction as well as supporting the local economy. Supporting local sources is a trend that we saw throughout all four of the cases studies. A large on site tank should be used to harvest rainwater to utilize both inside the building and throughout the exterior landscape. The building would be well equipped with low flow toilets, faucets, and showers to help reduce water consumption. The residence hall should be built with no volatile organic compounds so there are no potentially harmful substances in the building. The building should be built with large windows to allow for natural lighting and airflow to maintain healthy indoor air quality. Occupancy sensors should be installed to optimize lighting efficiency and all energy information should be recorded via an energy dashboard so the residents' energy consumption could be displayed to them in a direct fashion. A green guide should identify all of the sustainable features throughout the building so that the residents and visitors can familiarize themselves with the building's surroundings. The residence hall will be categorized as a living-learning laboratory where residents take a hands on approach in maintaining the building. This will help the residents understand the infrastructure of the building so it is utilized to its full potential.

We proposed this residence hall based on the findings of our research and because it also complies with WMU's commitment to sustainability. The proposed residence hall will provide students with a living learning opportunity as well as a sustainable living option that they currently do not have. This proposed residence hall would also be a very good response to the results of the student sustainability survey where the majority of students responded saying both sustainable living and infrastructure are important issues to address on campus. Additionally this building will help in WMU's overall goal of becoming carbon neutral by 2065.

WMU is in the planning process of building two new residence halls on campus in place of Bigelow and Hoekje Halls, which will torn down in the summer of 2013. Because of this there is a lot of further research that could be done on super green residence halls. Additional case studies could be done on other universities to find out as much information as possible. Along with this economic benefits and costs and a life-cycle analysis of the residence halls should be determined to help in the planning process of the new residence halls at WMU.

IV. Introduction

Western Michigan University's vision is to be "learner centered, discovery driven and globally engaged" (Western Michigan University) every aspect of the university should mirror these values. WMU values sustainability and is searching for new ways to foster a sustainable campus culture. Residence Halls are a living, learning community that allows students the opportunity to learn outside of the classroom. The issue being addressed is that the WMU students are not currently provided with on-campus living communities that foster sustainable living or learning. We plan to investigate the incorporation of sustainability within other universities on-campus living. Our current hypothesis is that implementing a super-green residence hall at WMU will provide student's experiential learning that promotes a more sustainable campus culture that better exemplifies WMU's vision.

Western Michigan University's actions leading up to present day have shown its commitment to sustainability. Throughout the years WMU has committed to initiatives such as the Talloires Declaration and the American College and University Presidents Climate Commitment (ACUPCC). They have also redefined sustainability within the campus mission in order "to enhance responsible environmental stewardship" (Western Michigan University). WMU is also a member of the Association for the Advancement of Sustainability in Higher Education (AASHE) and from preliminary research we were able to find sixty other universities that are members of AAASHE who have incorporated sustainable residence halls on their campuses (view Appendix 4). In 2010, WMU students voted in support of a $8.00 sustainability fee for student sustainability projects which resulted in WMU being the first campus in Michigan to demonstrate such efforts. Environmental sustainability has been integrated into the Academic Affairs Strategic Plan on top of a newly formed committee to measure "progress on sustainability and to begin to chart a course for our future" (Western Michigan University).

The four buildings that are being evaluated are LEED certified with one attempting to achieve Living Building Challenge petal recognition. There are currently two main building certification processes that address sustainable infrastructure: LEED and the Living Building Challenge. LEED, which stands for Leadership in Energy and Environmental Design, focuses primarily on energy efficiency through design that optimizes cost while simultaneously bettering the building's ecological footprint. LEED certification evaluates and categorizes buildings into four levels based on a scale of 110 credits. Buildings are able to earn a basic certification or a level of silver, gold, or platinum. The buildings are evaluated on sustainable sites, water efficiency, energy/atmosphere, materials/resources, indoor environmental quality, innovation in design/operations, and regional priority credits. Platinum certification requires a building to earn eighty credits or above and to achieve a Gold certification the building must obtain anywhere from sixty to seventy-nine points (LEED 2009 for New Construction and Major Renovations Rating System).

According to the International Living Future Institute, the Living Building Challenge (LBC) is an international building certification program created in 2006. The LBC is an advocacy tool and certification program that promotes an advanced measurement of sustainability. LBC can be applied to both new and renovated buildings and is based on seven main criteria: site, water, energy, health, materials, equity and aesthetics. Residence Halls are living, learning communities that allow students the opportunity to learn outside of the classroom. The issue being addressed is that currently WMU students are not provided with on-campus living communities that foster sustainable living or learning opportunities. This analysis will investigate the incorporation of sustainability within other universities on-campus living. The current hypothesis is that implementing a super-green residence hall on campus will provide student's experiential learning that promotes a more sustainable campus culture that better exemplifies WMU's vision.

V. Methodology and data

To analyze the problem of not having a sustainable living situation available for students on campus we performed a best-practice analysis of other campuses that incorporate sustainable residence halls for students. We gathered basic data for sixty different residence halls including: name of the college or university, name and function of the building, the year the building was completed, sq.ft. of the building, number of beds, cost of construction, cost of room and board, tuition (in-state), if they were a member of the AASHE, if they were a signed ACUPCC, what the LEED certification was, if they achieved the Living Building Challenge, and any additional comments. After gathering this data we narrowed our research down to four different buildings to perform a full case study on. To help us have a better understanding of sustainable infrastructure we also attended a learning unit that offered us an introduction to the Living Building Challenge. After attending the talk we earned a certificate of completion from the International Living Future Institute recognizing our knowledge of the Living Building Challenge.

Out of the sixty preliminary buildings researched, we decided on University of Colorado Boulder, University of Notre Dame, Berea College, and Warren Wilson College to complete an in-depth case study. These four universities allowed us to evaluate buildings from a broad perspective. Berea College's Deep Green Residence Hall and Warren Wilson's Ecodorm are two examples of residence halls that are pushing the boundaries on sustainable living options for students. These dorms will allow us to analyze cutting-edge features that could potentially be implemented in a residence hall at WMU. UC Boulder's Williams Village North Hall is a very large residence hall, with 500 beds, that has achieved a LEED Platinum certification. UC Boulder is similar in size, in terms of enrollment, to WMU (where as Warren Wilson and Berea are both much smaller), which is why we choose to do a case study on their residence hall. We also choose to look into Notre Dame University's Ryan Hall, which is a middle-sized residence hall with 228 beds that earned a LEED Gold certification. This hall was chosen to give an example of a sustainable living option that does not push the boundaries on sustainability. This will allow us to determine if it is possible to achieve the "super green" aspect of a residence hall without explicitly incorporating a sustainability related theme into the residence hall. Additionally we choose these residence halls because we wanted to have a wide variety of options to best analyze what would best work at WMU.

The in-depth case study allowed us to find further information on the sustainable features implemented into the residence halls as well as the educational components at each institution. We were also able to find information on the actual energy use of each residence hall in terms of kWh/sq.ft. This information allowed us to make comparisons to the actual energy use of the average residence hall on WMU's campus, which was provided by Chris Caprera (Facilities Management at WMU). The chart below compares each residence hall in the case studies and WMU to compare the sustainable features.

Figure 1

	Warren Wilson	Berea	Notre Dame	UC Boulder	Western Michigan University
Residence Hall	Ecodorm	Deep Green Residence Hall	Ryan Hall	William Village North Hall	Valley I
Occupancy	36	121	248	500	1000
Total sq.ft.	9146	41759	74000	131246	324464
kWh/sq.ft.	0.0228	N/A	1.8	4.7	17.8*
Year Built	2003	Aug-13	2009	2011	1963
LEED Certification	Platinum EB	Platinum	Gold	Platinum	N/A
Living Learning Laboratory	Yes	N/A	No	No	No
Solar Panals	Yes	Yes	No	Yes	No
Low-flow faucets/Toilets	Yes	Yes	Yes	Yes	No
Wind Turbines	No	No	No	No	No
Uses Recycled Materials	Yes	Yes	Yes	Yes	No
Energy Dashboard	Yes	Yes	Yes	Yes	No
Rainwater Runoff Use	Yes	Yes	No	Yes	No

Occupancy Sensors	Yes	Yes	Yes	Yes	No
HVAC	Yes	Yes	Yes	Yes	Yes
Geothermal Heating	Yes	Yes	No	No	No

**Includes the energy usage of a dining facility*

To get more information about the programs offered through the Williams Village North Hall, Matthew Nock, the Sustainability Coordinator for Williams Village North Hall, provided first hand knowledge on the educational programs offered to the residents in the building as well as the total energy use demand for the building. For a more in depth review of Berea College's Deep Green Residence Hall, Steve Karcher, VP of Operations and Sustainability to provide a perspective on the new building being developed for August 2013. In order to find more information regarding the Ecodorm, we contacted Stan Cross who is the Interim Director for the Environmental Leadership Center at Warren Wilson College. During a phone interview at 10:00 a.m. on Friday April 12th we asked him the following questions:

- Were there any difficulties/challenges with the project?
- How do students get to live in the Ecodorm?
- Has a post assessment on behavior change ever been completed?
- Is the Ecodorm more competitive than the other dorms?
- What is the plan for the Ecodorm now?

We found data on a few current residence halls on WMU's campus, including Valley I along with the Western View Apartments. This data allowed us to compare the current options for on-campus housing to the sustainable residence halls of each case study. To go along with the WMU campus opportunities we incorporated questions about sustainable residency on the Student Sustainability Survey. The questions in the survey can be found in Appendix 3. These questions will allow us to analyze the interest that the student body at WMU has in super green residence halls. All of this data together will allow us to make an appropriate suggestion to the WMU administration on incorporating sustainable living options for students at the university.

VI. Examples of best practice on campus

Current campus residence halls at Western Michigan University incorporate very little sustainable design. The majority of incoming students live in "The Valleys" so for the on-campus case study of WMU we will first look at the sustainability of Valley I. Valley I is a single building erected in 1963, comprised of four residence halls (250 residents each) and a cafeteria. The building is 324,426 total square feet and uses an average of 17.8 kWh/sq.ft. Because of the cafeteria this energy use can be difficult to narrow down to specific consumption of each residence hall.

Another living option on WMU's campus is the newly built Western View Apartments (Phase 1). Phase 1 consists of four buildings that were just recently built in 2010 and are LEED certified. This apartment style living has sustainable features such as access to public transportation, water-efficient fixtures, energy star appliances, HVAC equipment, 10% use of recycled materials, low-emitting VOC's, and thermal insulation. Building's 1-4 come to a total of 145,041 square feet and house a total of 300 beds.

VII. Examples of best practice on other campuses

Case Study of Notre Dame University's Ryan Hall

Overview:

In 2009 Notre Dame built Ryan Hall, which is a 74,000 sq.ft. residence hall with a Leadership in Energy and Environmental Design (LEED) Gold certification. Ryan Hall is one of twenty-nine residence halls on Notre Dame's campus and houses 248 female students. Eighty percent of students at Notre Dame University live on campus in the residence halls. Each residence hall builds its own sense of a community, and it is very common for students to remain in the same residence hall for their whole college career.

LEED Gold Standards:

LEED Certifications are based on a point system where points are earned on sustainable features in five main categories: sustainable sites, water efficiency, energy and the atmosphere, materials and resources, and indoor environmental quality. There are also two potential bonus categories involved with the planning of the building including innovative design and regional priority where extra points can be earned. The LEED 2009 New Construction certification was based off a one-hundred point system, with ten additional bonus points, and to achieve a Gold certification the building must obtain anywhere from sixty to seventy-nine points (LEED n.p.).

Sustainable Design Features:

Ryan Hall has included many sustainable features during the construction process of the residence hall. Thirty-nine percent of the materials used were extracted and manufactured within a five hundred mile radius of the campus and the materials also included thirty-one percent pre- and post-consumer recycled materials. Additionally 970 tons of the construction waste material was recycled for other building projects, diverting it from landfills (Notre Dame Sustainability n.p.). The building site was also chosen specifically within a quarter-mile of two different campus bus stops to encouraging the use of public transportation and a decrease of students driving. The residence hall has public bathrooms that use low flow urinals, faucets, showerheads, and dual-flush/low-flush toilets, which allow the building to use thirty-two percent less water than standard fixtures. The residence hall also features automatic lighting controls, special lenses on the outdoor fixtures to help reduce light pollution, along with ninety-one percent of the space in the building open to natural sunlight (Notre Dame Sustainability n.p.).

(Note: photos from University of Notre Dame Campus Tour)

Educational Components:

Notre Dame University incorporates different sustainability-related educational components into their residence halls. One main component is a real time energy dashboard available for students to view on the university's website. The dashboard is incorporated into a competition between all residence halls to use the least amount of energy. Allowing the students in the residence halls to access the dashboard and see their real-time energy use is meant to invoke a behavior change for the students to become more aware of their energy usage, therefore resulting in lower electricity consumption. Incentivizing the competition also encourages the students to decrease their energy consumption.

Another educational component of all Notre Dame residence halls is a light bulb exchange program. At the beginning of each year a group of students go door-to-door in the residence halls offering to exchange any incandescent light bulbs with more efficient compact fluorescent light bulbs. This program also encourages behavior change by educating the residents on the potential benefits from having more energy efficient light bulbs, and also encouraging the residents to turn off the lights (and any other device using energy) when not in use.

Actual Energy Usage:

The energy dashboard tracks energy and water usage in real-time for twenty-nine different residence halls on Notre Dame's campus. It includes total energy usage, energy use per square foot, and energy use per person for building comparisons. Out of all of the buildings listed, Ryan Hall is number eight in the top ten buildings for the most kWh/sq. ft. In *Graph 1* you can see the kWh/sq. ft. comparison for Ryan Hall, O'Neill Hall (most energy use), and the two residence halls that use the least amount of energy: Lyons Hall and Howard Hall. *Graph 2* also shows the year-to-date CO_2 emissions between Ryan Hall and Lyons Hall (note: Lyons Hall does not have and type of LEED certification). Residents in Ryan Hall used 543 kWh/person and 1.80 kWh/sq.ft., while in Lyons Hall the residents only use 156 kWh/person and 0.41 kWh/sq. ft.

Figure 1:

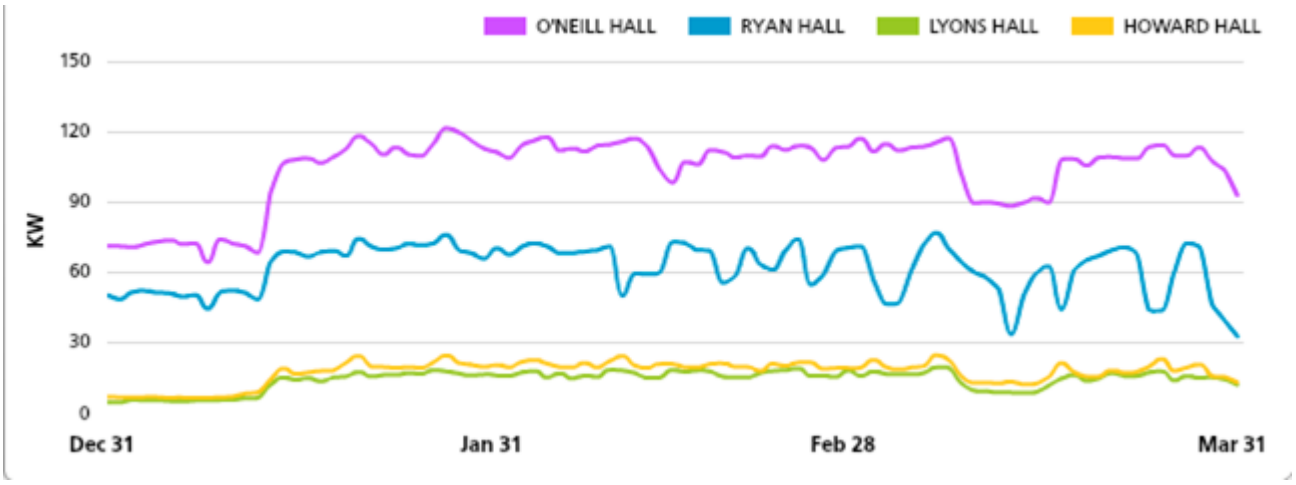


Figure 2:

Ryan Hall

Lyons Hall

Conclusion:

The data shows that Ryan Hall, although LEED Gold Certified, does not actually perform better than other residence halls at University of Notre Dame in terms of energy use and CO_2 emissions; it actually does significantly worse in these aspects. This is a good example of how the LEED certification process is not effective. Ryan Hall received many of its points for gold certification in the materials and resources and indoor environmental quality sections, but lacked a significant amount of points in the water efficiency and energy and the environment aspects. Out of twenty-nine dorms on the university's campus, Ryan Hall consumes the sixth most total energy and the eighth most energy per sq.ft. and per person. An explanation for this could be that there is something else going on in the residence hall, such as a cafeteria, that is consuming more energy and not being accounted for in the energy dashboard. More research will need to be done to determine if that is the case, or if the residents are actually consuming all of the energy.

University of Colorado Boulder
Williams Village North Hall
Case Study

Overview:

University of Colorado Boulder has several LEED certified buildings on campus, but Williams Village North Hall stands out among all of them. Williams Village North Hall houses 500 students and opened in August 2011. It was the first LEED Platinum certified university residence hall of its size. This hall offers on-campus living, community meeting spaces both inside and outside, classrooms, faculty offices, a computer lab, and several study areas throughout the hall.

Sustainable Design Features:

Williams Village North Hall contains many sustainable features that qualified it for the LEED Platinum certification. The entire residence hall cost $46.5 million with about 1.5% of the total cost was related to the sustainability features in the hall (Anas, 2011). Williams Village was built to maximize direct solar heat through the windows of the building during the winter and sunshades were incorporated to minimize the amount of direct solar heat in the summertime. For domestic hot water usage, the water is partially heated through solar energy. The roof was also designed to have a high Solar Roof Index (SRI) to reduce the heat-island effect. 12.5 percent of the energy used by the building comes from the photovoltaic solar panels that are on the south-facing roof of the building. An HVAC sensory system stops the heating/cooling of the building when the windows are open. A CO2 monitors provide need-based ventilation for better indoor air quality with reduced energy consumption. The building also utilizes different ways of limiting artificial light by installing daylight sensors, to adjust the amount of artificial light as well as implementing occupancy sensors to turn off artificial lighting when a space is not being used. There are light shelves installed to increase natural light into the interior of the building. The landscape around the building was designed to use as little water as possible. Williams Village also uses a gray-water reuse system as well as using

storm water runoff for any additional landscaping needs. The building has low flow toilets, showerheads and faucets installed to reduce the water use by 40%. Williams Village North was also constructed with regional and rapidly renewable materials and materials with high-recycled content. Williams Village North Hall also has an energy dashboard located in the lobby of the building that displays the amount of energy that is being used.

Educational Components:

On-campus living is a great opportunity to help students to develop and learn outside of the classroom and that is why University of Colorado Boulder offers learning communities in the residence halls. Williams Village North Hall offers three learning communities within the residence hall focused around sustainability, and students must apply to be a part of the learning communities within the hall.

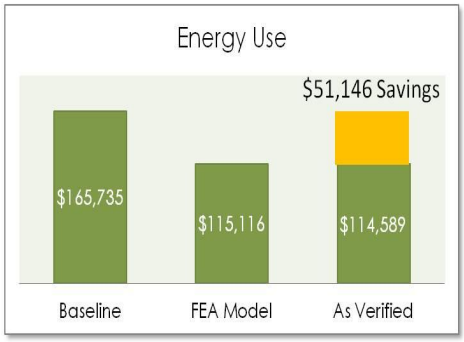
- SEEDS (Social Entrepreneurship for equitable Development and Sustainability) is a learning community for students in all majors that are concerned about sustainability and innovation and who want to be actively involved in developing solutions. This program also offers residents the opportunity to earn credits toward their degree.
- Active Living and Learning Community - is a community within the Williams Village West Hall that engages students in living an active lifestyle outdoors. This community offers residents the opportunity to experience nature together on hiking trips, rock climbing and mind/body activities like meditation or yoga.
- Sustainable By Design Residential Academic Program is a community available to students of any major, which provides the opportunity for students to learn about resource-efficient design, renewable energy, and the environmental and social impacts of community development. These residents will be learning from the building they are living in and will also be able to earn credits towards their degree. "Williams Village North Hall offers more than a living space, it offers a lifestyle" said the executive director of Housing and Dining Services at University of Colorado Boulder in an interview with a local newspaper.

Energy Usage:

The total energy use for this building is 622,000 kWh per year, which is 30% below the baseline amount. Williams Village is a total of 131,246 square feet (about the same size as Britton Hadley halls in Valley 1 combined). The baseline amount refers to the amount of energy that a building of this square footage would normally use (M.Nock, personal communication, April 9, 2013). Additionally, 12.5% of the energy used comes from the onsite solar panels. *Figure 1* displays energy use in terms of costs to the university. The amount of money saved on energy each year in Williams Village North Hall due to the energy saving sustainability features, the building will pay for itself in a total of ten years. *Figure 2* displays the bar chart from figure 1, the peak electricity demand, the total electricity consumption, and the natural gas consumption. Overall, Williams Village North consumes less energy, money, and natural gas than a building of identical size while also utilizing alternative energy to supply power to a portion of the energy that is consumed.

Figure 1

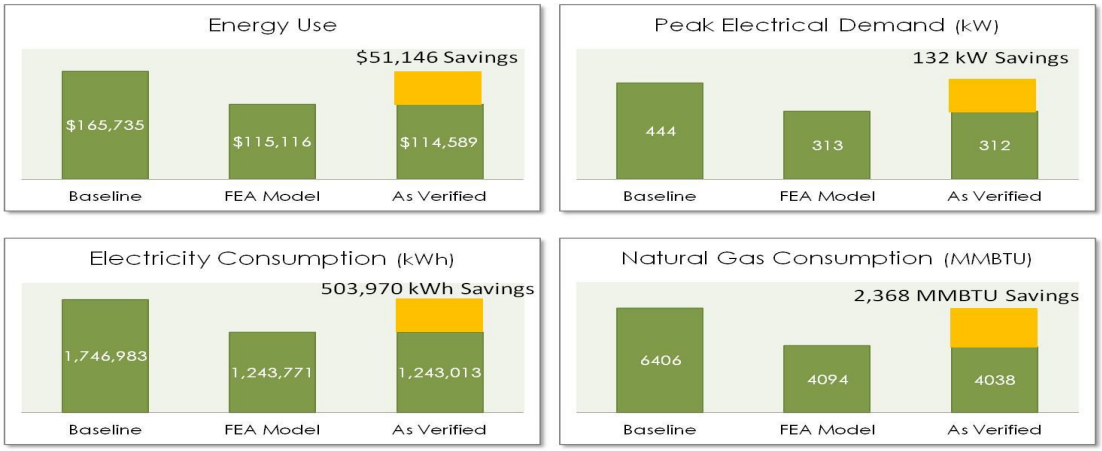
University of Colorado Boulder
Annual Energy Performance vs ASHRAE 90.1-2004 Baseline



Incremental construction cost	$ 555,000
Xcel Energy incentive	$ 39,600
Adjusted incremental construction cost	$ 515,400
Annual energy cost savings	$ 51,146
Payback with incentive (in years)	10.1 years

Figure 2

University of Colorado Boulder
Annual Energy Performance vs ASHRAE 90.1-2004 Baseline



On-Campus Community:

University of Colorado Boulder has more than 30,000 students with 7,000 of the students living on-campus in 22 of the university's residence halls. The university offers many learning communities within the halls across campus that focus on different subject areas, including sustainability. Williams Village North Hall is not the only LEED certified residence hall, but it is highest ranked as well as offers the most sustainable focused learning communities to the residents.

Conclusion:

Williams Village North Hall offers the opportunity for a large amount of students to live in a sustainable community, and also offers the experience of a small, sustainability focused, learning community. For a building of its size, Williams Village North has been successful in reducing energy usage as well as incorporating new ways to involve students in sustainability. The energy use for Williams Village North Hall is 30% less than the average building of the same size. This building isn't located directly on campus, and therefore fills up slower than the on-campus halls. Not only does the building implement sustainable design features to lower energy consumptions but also offers a place for students to learn to live sustainably. The living communities receive a high number of applications to live in the community and earn course credit, while learning to lessen their impact within the hall and experience the environment around them. Williams Village North Hall was the first LEED platinum building of its size and was able to cut back energy by implementing different design features by 30% and then utilize solar energy to power a little over 12% of the energy consumption. This building is still consuming a large amount of energy and although it has made significant cutbacks in consumption, the building is not at net zero carbon and is still negatively impacting the environment.

BEREA COLLEGE: DEEP GREEN RESIDENCE HALL

"The College's ultimate goals must be (1) to become truly sustainable, that is to operate without negative physical impact on the lives of others in the world, and (2) to have positive impacts on the world through education, through the creation of a model sustainable community, and through practical engagement with other local sustainability initiatives." ("The Strategic Plan For Berea College")

Overview:

Berea College is a liberal arts college located in central Kentucky. This nationally recognized work college provides each of the 1,613 undergraduate students full-tuition scholarships worth $20,900 for each of the four years attending. Demonstrating its dedication towards sustainability, Berea provides 90 percent of students immersive, simple living residential options through both the EcoVillage apartment complex and the Sustainability and Environmental Studies (SENS) house. In 2010, Berea developed plans for a $12 million larger residence hall to house over a 100 students that would model the greatest scale of sustainability for the campus community. The Deep Green Residence Hall will be open for Fall 2013 to reflect Berea's definition of sustainability.

Berea College will open the Deep Green Residence Hall in August 2013 for 121 students to reside in 66 rooms. The intentions for the Deep Green Residence Hall is to be a "Learning By Living Lab" by integrating education with the construction and design of a sustainable building. This residence hall is 41,759 square feet, three floors high and on track for LEED Platinum certification as well as potential Living Building Challenge "Petal Recognition." ("Sustainable Learning, Simple Living | DEEP GREEN Residence Hall.")

LEED Platinum Standards:

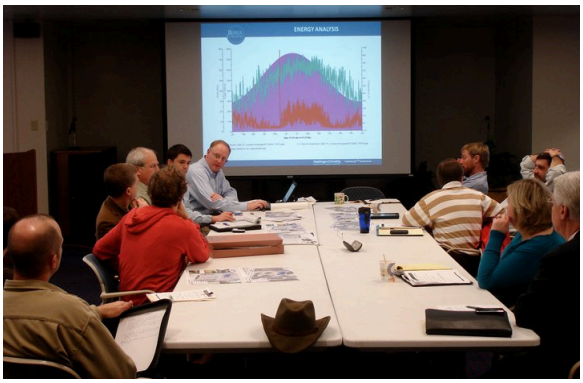
Platinum certification requires a building to earn 80 or above credits. The Deep Green Residence Hall will acquire this status. All wood material used within the hall is FCS certified. Ninety-two percent of construction waste is being diverted from landfills. Seventy-five percent of building materials were gathered within 500 miles of the project. Fourteen percent of all energy usage is renewable energy from on site of the project. Fifty-five percent reduction of energy consumption and forty-four percent reduced water demand.

Living Building Challenge:

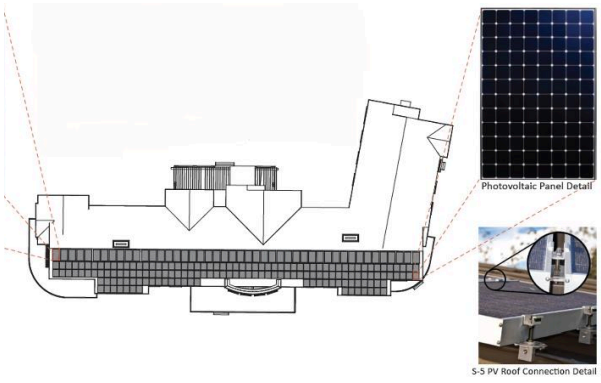
This residence hall is also on track to receive "Petal Recognition" in Site, Health, Materials, Equity and Beauty. Each of these "petals" has imperatives required for the building to be certified. Site consists of Limits to Growth, Urban Agriculture, Habitat Exchange, and Car Free Living. Health consists of Red List, Embodied Carbon Footprint, Responsible Industry, Appropriate Sourcing, and Conservation/Reuse. Equity has Human Scale/Humane Places, Democracy/Social Justice, and Rights to Nature. Beauty consists of Beauty/Spirit and Inspiration/Education.

Sustainable Design Features

Berea College started planning this residence with two design firms; Hastings + Chivetta and Hellmuth + Bicknesse. These two firms provided insight on both interesting small sustainable designs and large solid LEED Gold residence halls. Together with students and faculty, small focus groups and workshops were immediately created to discover potential and create new educational opportunities for students.



This residence hall also has sustainable design features that contribute to its green design in energy efficiency. Solar energy accounts for 14 percent of the building's energy needs through a 50 kW solar photovoltaic used for its electricity and hot water systems. To reduce heating, ventilation, and air conditioning costs by 50%, Berea invested in a geothermal heat pump recirculation system. There is high efficiency lighting, insulated state-of-the-art building envelope, low-flow water fixtures and rooms will have operational windows for a more natural ventilation system. The woods cut down for building construction furnishes the inside of the building and were mule logged out of the FCS-certified forest for a more sustainable transportation. Rain gardens, bio-retention ponds, and



pervious concrete help manage storm water runoff. The building also has a dashboard that provides real-time monitoring of energy consumption.

Educational Components

The Deep Green Residence Hall incorporated a variety of educational opportunities during the entire construction process of the building. Before construction started, students participated in an archeological site dig. The wood for interior trim and furniture and the decorate sundial for the exterior of the building were all built by students and faculty.

(Note: photos taken from Berea_LiveGreen Facebook)

The "building dashboard" is intended for faculty and students to gauge energy usage in the halls to create conversation on personal and commutative energy usage. Students who have expressed a desire to participate in water use-reduction competitions will monitor water consumption. Urban agriculture is also available for students.

Actual Energy Use:

This building is predicted to have a Energy Usage Intensity of 30 to 32, when the national average for residence halls are 90 per square foot. This building has not yet been built so actual energy quantity usage is not provided. ("Sustainable Learning, Simple Living | DEEP GREEN Residence Hall.")

Conclusion:

The Deep Green Residence Hall at Berea College is an energy efficient building that actively demonstrates a sustainable philosophy through residence hall design. The building will be LEED Platinum certified and is striving Living Building Challenge "Petal Recognition." It has incorporated students, faculty, and the community into the design and construction in hopes of creating a greater education opportunity. The initial planning for the Deep Green Residence Hall resulted in the student-made furniture, archeological dig, the artistic collaboration with ceramic courses and educational courses. The connection with campus is intended to create more immersive and sustainable behavior change- "living by learning."

Case Study of Warren Wilson College's Ecodorm

Overview:

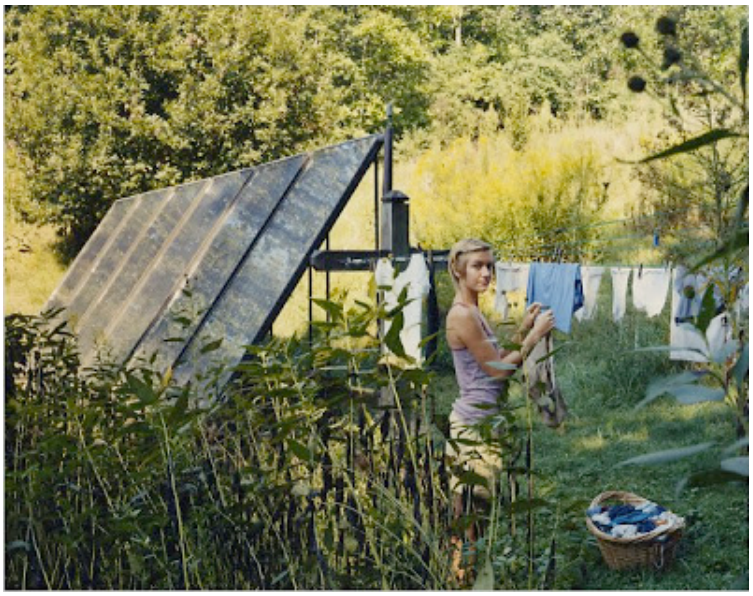
The concept of the Ecodorm was initiated by a couple of students in 1998 during a residence hall rebuilding process on campus. The purpose for the rebuilding process was to increase enrollment throughout the college and after hearing plans about the new construction, the student's urged the administration to build a 'green dorm' that was aligned with the values and morals of the college. Soon after the students began working with the administration and design team on the Ecodorm project. The project's official meetings began in 2001 and completed the dorm in summer 2003. Students go through a lottery process in order to be admitted into the Ecodorm. Once in the Ecodorm, the student now has 'squatter's rights', meaning that they can stay in the dorm as long as they like, but cannot once graduated.

LEED Platinum Existing Building Standards:

The Ecodorm is rated under LEED EB V-2.0 and achieved a Platinum certification.

Sustainable Design Features:

Warren Wilson College incorporated many sustainable features into the Ecodorm. They used wood from their own forests that were dead or damaged due to pine beetle infestation. In order to have a sound building envelope they used SIP's or structural insulated panels that were purchased from a manufacturer in Michigan. The roof of the building is made out of recycled steel, which has long life expectancy. 1.4 Kilowatt of photovoltaic rays help provide a portion of the electricity needed for the building. The building also uses solar panels to preheat water before it goes into a 10,000-gallon on-site recycled tank where all the collected rainwater is fed to support flushing toilets and outdoor water spigots. High efficiency boilers are used to further heat the water for the occupants use. There are also two composting toilets that the residents maintain every 2 weeks.



The inside of the dorm hosts a plethora of recycled materials from various different places found locally such as broken or old tiles found in factories and 24% fly ash, which is a byproduct of coal burning, that is used for cement production. A radiant in floor heating system is used to control temperature within the building by circulating heated water beneath the floors. In order to maintain good indoors air quality there are heat recovery ventilators that operate mechanically as well as ceiling fans in many of the rooms. They also incorporate certain species of plants to improve oxygen in the building. All appliances in the building are energy star rated and the college prohibits mini-fridges and toaster ovens. To minimize energy consumption the building has ultrasonic sound devices (sensors) that control the lighting in the rooms based on occupant use. The dorm also has a monitoring system (Direct Digital Controls) that monitors the consumption of the following: natural gas, water, grid electricity, PV electricity production, solar hot water panels, and heating system equipment.

Educational Components:

The residents of the Ecodorm have a full educational learning experience while they reside there. "Students who choose to live in the Ecodorm are adopting a lifestyle." (Ecodorm manual) This living learning laboratory requires the students to learn how to maintain the building and opt for a lifestyle that challenges them both physically and mentally.

Students that live in the dorm work 15 hours a week. They are in charge of harvesting and maintaining the permaculture landscape, rake the compost toilets and manage food compost, as well as keeping up with general cleaning. They also forgo luxuries such as televisions and using dryer machines. On top of maintenance, the residents also host eco-cultural events. These events bring not only the college community together but also the local community as well.

Actual Energy Usage:

The Ecodorm monitors its energy consumption by using a Direct Digital Control system. There is a digital computer screen located in the common room and information can be accessed via the Internet so that the residents can monitor their consumption as well as analyzing statistics. The DDC system monitors the heating system, solar hot water panels, PV electricity production, grid electricity used, city water and rainwater, as well as natural gas. "Overall, the building uses 69% less energy than a conventional building of the same size" (M. Flood, "Warren Wilson College EcoDorm Is First Platinum Dormitory in the Nation"). The most recent energy analysis completed by the Ecodorm was in December of 2008 and data showed the Ecodorm used total energy consumption of .0193 kWh/per sq. ft.

Conclusion:

Warren Wilson College's Ecodorm has been a great success for the college. According to Stan Cross, the dorm improved enrollment and retention by providing an experience where students challenge themselves by limiting their environmental impact and develop sustainable behavior change. The sustainable features found in the dorm act to improve energy efficiency of the building and act as a driving force for responsible consumption. The living learning laboratory creates an atmosphere in the Ecodorm that helps improve environmental awareness, promote mindfulness, and teach people to be more community driven. All of the residents continue to use the skills and knowledge learned through the Ecodorm experience far into the future.

VIII. Discussion

Western Michigan University is currently one of 665 universities who have signed the American College and University Presidents Climate Commitment, creating an active plan for campuses to become carbon neutral by 2065 (President's Climate Commitment). The University is also one of 350 universities to sign the Talloires Declaration, which is the initiation of a ten-point action plan for sustainability literacy in research, teaching and operations. This increasing sustainable mission trend for universities is understood by the increasing demand for sustainability from students. Sixty-nine percent of 2011 college applicants said information regarding a university's commitment to environmental issues would contribute to their decision to apply/attend a certain college or university ("The Financial Benefits of Campus Sustainability," Princeton Review).

We also incorporated sustainable residency related questions into the Student Sustainability Survey to find out how students from WMU feel about the issue. The results show that 66.32% of students view expanding the green portfolio on buildings on campus is an important step that should be taken into consideration when developing infrastructure. Additionally 66.46% of students responded that expanding sustainability focused housing on campus is an important concern, with 406 students saying that sustainable residence halls were the "most important" issue by answering with a 5.

Three of the top requests by students were to decrease the University's GHG emissions, expand sustainability focused residential options, and expand the portfolio of green buildings, which all can be directly addressed through the incorporation of a super-green residence hall at WMU. We saw this happen through the case studies of the super green residence halls do at UC Boulder, Warren Wilson College, and Berea College. Additionally, the most important overall issue according to the students who took the survey was to reduce landfill waste, which was reduced drastically in the construction/deconstruction process of UND's Ryan Hall, and is also addressed through the "living learning laboratory" lifestyle of the Ecodorm at Warren Wilson.

Figure 2

	Response Total	Response Average
Reduce WMU's landfill waste.	1152	4.04
Increase and expand local, healthy, and sustainable food options on campus (including special diet options such as gluten-free).	1154	4.01
Reduce WMU's greenhouse gas emissions.	1135	3.92
Expand sustainability focused residential options on campus (i.e.-green dorms or apartments).	1154	3.79
Expand WMU's portfolio of green buildings.	1140	3.77
Expand opportunities for sustainability-related paid internships and part-time student jobs.	1146	3.68
Decrease automobile use to, from, and around campus by making it easier to commute by public transit, carpooling, bikes, walking, etc.	1152	3.65
Expand sustainable agriculture on campus (i.e. community gardens and/or farming on campus).	1145	3.59
Increase sustainability offerings in majors, minors, and graduate programs.	1145	3.46
Increase the availability of space on campus for students to play music, display	1147	3.41

art, recite poetry, or express themselves in other ways.		
Expand opportunities for funded campus sustainability-related graduate research.	1144	3.35
Create a sustainability certificate program.	1144	3.3
Increase the number of sustainability related general education courses in the curriculum.	1142	3.21
Hold additional sustainability related events on campus.	1148	3.21

Right now there are seven LEED certified buildings on WMU's campus, however none of these options actively engage student population with regards to deep green sustainability. Western Michigan University's enrollment rates have declined 5.9% from Fall 2011 to Spring 2013 ("Office of Institutional Reports"). As demonstrated by Warren Wilson College having a sustainable residence hall can help increase admissions (Warren Wilson EcoDorm). In order to meet this demand, Western Michigan University will have to take great strides in sustainable design and integration to inspire recruitment and retention of student populations.

In an interview with Marley McVey, a previous resident of the LEED certified Western View Apartments, she stated that the apartments did not incorporate any sustainable education that resulted in behavior change. She also chose to move off campus and not return to the apartments because she was not satisfied with the quality of life this LEED certified building provided. According to Stan Cross, the Interim Director for the Environmental Leadership Center at Warren Wilson College, Warren Wilson's residence hall's integrated "living laboratory" has vouched for both increased enrollment and quality of life.

Along with increased enrollment, having a "living laboratory" residence hall program increases the integrity of the university and education available for students. At the University of Colorado Boulder, students are given the opportunity to earn college credit for participating in the Residential Academic Program. The Deep Green Residence Hall from Berea College and Warren Wilson incorporated student involvement in the initial planning process as an alternative approach to "living by learning." Both Berea and Warren Wilson also helped in the physical building process as an additional learning component. Berea conducted 18 months of planning with faculty, students, and departments throughout the community to take advantage of all opportunities beyond "bold and cutting edge sustainable design features" (S. Karcher, personal communication, April 9, 2013).

Based on the data gathered from the case study on Ryan Hall from the University of Notre Dame we recommend that the construction of new residence halls at WMU make it a priority to focus on the actual energy usage and efficiency, rather than only attempting to achieve a certain LEED certification. Ryan Hall did a good job of incorporating sustainable features in the design and construction of the building, however in terms of actual energy use the building did not perform well. An explanation for this could be that since the students knew they were living in LEED Gold certified building; they did not feel accountable for their ecological footprint. This is sometimes referred to as the "prius effect" which is a phrase to explain how consumption of a sustainable product can increase to a level where it becomes the less sustainable option. This is something that residence halls at WMU should be sure to avoid, which can be done by incorporating behavior change aspects into the living situation.

Here are the major commonalities in regards to sustainable design features that we found when analyzing the four case studies:

Figure 3

	Warren Wilson	Berea	Notre Dame	UC Boulder	Western Michigan University
Residence Hall	Ecodorm	Deep Green Residence Hall	Ryan Hall	William Vilage North Hall	Valley I
Occupancy	36	121	248	500	1000
Total sq.ft.	9146	41759	74000	131246	324464
kWh/sq.ft.	0.0228	N/A	1.8	4.7	17.8
Year Built	2003	Aug-13	2009	2011	1963
LEED Certification	Platinum EB	Platinum	Gold	Platinum	N/A
Living Learning Laboratory	Yes	N/A	No	No	No
Solar Panals	Yes	Yes	No	Yes	No
Low-flow faucets/Toilets	Yes	Yes	Yes	Yes	No
Wind Turbines	No	No	No	No	No
Uses Recycled Materials	Yes	Yes	Yes	Yes	No
Energy Dashboard	Yes	Yes	Yes	Yes	No
Rainwater Runoff Use	Yes	Yes	No	Yes	No
Occupancy Sensors	Yes	Yes	Yes	Yes	No
HVAC	Yes	Yes	Yes	Yes	Yes
Geothermal Heating	Yes	Yes	No	No	No

IX. Limitations of your analysis and proposed future work

Throughout the project there were a series of limitations faced by our group. Since there was no prior research done on the subject of sustainable residence halls, there was nothing to base our analysis off of. As we were completing our preliminary research, information not accessible via the Internet limited our data. Another problem was that when we were gathering information for each case study, we could not find conclusive data on the impact each residence hall had on behavior change. Also, we wanted to incorporate energy data regarding the Western View Apartments (Phase 1); however, we were not able to because that information is linked to Consumer's Energy, which is private. We also interviewed a former tenant of the Western View apartments, but it would have been beneficial if more students could have been surveyed from WMU and each case studies campuses.

We recommend speaking with Western Michigan University's Administration and Western Student Association about the lack of sustainability focused living options on campus. A WSA resolution and open dialogue with the Office of Student Affairs would initiate plans for action. Along with this, in an attempt for a more comprehensive analysis of sustainable residence halls, we also recommend further research that could be done to answer the following questions:

- How successful were the sustainable features and did their outcome match the intended predictions?
- Were the educational programs that were incorporated in the residence hall successful? If yes, how so?
- Will the building pay for itself with energy savings? If so, when?
- What is the happiness level/quality of life of the residents in this hall compared to other residence halls? How can you tell?
- How do the long term/initial costs of WMU's current residence halls compare to the costs of the super green residence halls?

Lastly, further research can be done to be incorporated into WMU's plans to build two new residence halls in place of Bigelow Hall and Hoekje Hall. Because we had to lay the groundwork on the research and best practice of other residence halls, the plans WMU has for these new residence halls were not explored.

X. Conclusions/recommendations

After reviewing the best practice analysis and in-depth case studies, we believe that incorporating a sustainable residence hall would be a tremendous opportunity for WMU. Implementing a super-green residence hall will further WMU as a research institution and will also help attract the future leaders of tomorrow. The residence hall meets WMU's needs and wants for a sustainable education opportunity and also reflects the University's mission statement.

> "Western Michigan University is a learner-centered, research university, building intellectual inquiry and discovery into undergraduate, graduate, and professional programs in a way that fosters knowledge and innovation, and transforms wisdom into action. As a public university, WMU provides leadership in teaching, research, learning, and service, and is committed to enhancing the future of our global citizenry." (Western Michigan University)

Based on the findings from the case studies we were able to determine the different building features that would best fit Western Michigan University. The new sustainable residence hall will incorporate both students and administration in the planning throughout conceptual and implementation process to provoke interest and education in the construction of the new building. Allowing students to be a part of the planning process is another excellent opportunity for WMU to provide students experiential learning. This planning will surround a new net zero carbon building that provides a quality deep green living-learning experience for residents and the entire campus. The cutting edge design technology will incorporate renewable infrastructure, locally sourced materials, and choices in high water, lighting, and energy efficiency options. This residence hall will also set a new standard of innovation for WMU helping to attract and retain students to our campus.

Western Michigan University has plans to replace both Hoekje and Bigelow Halls, having to replace more than 500 students. We suggest that the proposed building consist of about 150-200 beds, which will accommodate a large percentage of the students and still capitalize on the opportunity for students to experience a deep green living-learning experience. The residence hall should do everything possible to reach carbon neutrality through the utilization of renewable infrastructure such as PV arrays, geothermal energy, and wind power. Not only will this help in achieving a deep-green residence hall, but it also complies with WMU's climate action plan to become carbon neutral by 2065. To reduce water waste and consumption a large on site tank should be used to harvest rainwater to utilize both inside the building and throughout the exterior landscape. The building should also be equipped with low flow toilets, faucets, and shower. The residence hall should be built with as little volatile organic compounds as possible so there are no potentially harmful substances in the building and it should also incorporate large windows to allow for natural lighting and airflow; each of these features will help maintain healthy indoor air quality. All energy information should be recorded and displayed via an energy dashboard so the resident's are able to directly see their energy consumption in real-time. A green guide should identify all of the sustainable features throughout the building so that the residents and visitors can familiarize themselves with the building's surroundings. The residence hall will be categorized as a living-learning laboratory where residents take a hands-on approach in maintaining the building, which will help the residents understand the infrastructure of the building so it is utilized to its full potential.

Beyond the technical side of this building, there will be a focus on education that exceeds the standard acceptance of an energy-efficient building. A super green sustainable building is not only an environmentally efficient building, but also a building that will invoke long-term behavior change in students. Occupants will be more aware of their ecological footprint by creating components such as field experience credits working within the building, consumption evaluations, and campus sustainability problem-solving programs. This building will foster an exciting environment and will allow WMU to provide a state of the art education in sustainability.

Western Michigan University consists of a high population of students that feel a need for a more sustainable residence hall option. A behavior-focused residence hall will provide students with a living experience that, although may be initially more expensive or time consuming to the university, will positively engage the current college student population. The residence halls on Western Michigan University's campus do not properly exemplify a sustainable mission statement and do not initiate sustainable behavior change. This new residence hall will provide students the innovative and learner-centered experience they are looking for. This new immersive

sustainable residence hall will fill a void in the student's residential living options by providing an environment where young minds can engage in and celebrate a sustainable lifestyle.

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Appendix 3.

Student Sustainability Survey results:

	Response T	Response A
Reduce WMU's landfill waste.	1152	4.04
Increase and expand local, healthy, and sustainable food options on campus (including special diet options such as gluten-free).	1154	4.01
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Expand sustainability focused residential options on campus (i.e.-green dorms or apartments).	1154	3.79
Expand WMU's portfolio of green buildings.	1140	3.77
Expand opportunities for sustainability-related paid internships and part-time student jobs.	1146	3.68
Decrease automobile use to, from, and around campus by making it easier to commute by public transit, carpooling, bikes, walking, etc.	1152	3.65
Expand sustainable agriculture on campus (i.e. community gardens and/or farming on campus).	1145	3.59
Increase sustainability offerings in majors, minors, and graduate programs.	1145	3.46
Increase the availability of space on campus for students to play music, display art, recite poetry, or express themselves in other ways.	1147	3.41
Expand opportunities for funded campus sustainability-related graduate research.	1144	3.35
Create a sustainability certificate program.	1144	3.3
Increase the number of sustainability related general education courses in the curriculum.	1142	3.21
Hold additional sustainability related events on campus.	1148	3.21

Appendix 4.

Preliminary Research:

Appendix 4.

Preliminary Research

College	Name of Building	Function of Building	Completed:	SqFt of Building	# of beds	Cost of building	Cost of Living	Tuition (in-state)	AASHE	ACUPCC	LEED Certified	Living Building Challenge	Additional Comments
UC San Diego	Charles David Keeling Apartments	Residence Hall	2011	147000	516	N/A	$11924	$12192	Y	Y	Platinum	N	Key Features: natural cooling from ocean breezes, backwards constructed rainscreen and air barrier exterior wall, rooftop photovoltaic array
Harvard University	McCulloch Hall	Residence Hall	2010	35127	84	N/A	$10800	$53500	Y	Y	Platinum	N	Key Features: occupancy sensors that set back temperatures when the room is unoccupied, daylight sensors, LED task lighting, efficient overhead lighting, and fixtures to reduce potable water consumption by more than 30 percent
University of Colorado Boulder	Williams Village North Hall	Residence Hall	2011	131246	500	$46.5 million	$5,500 - $7,000	$9664	Y	Y	Platinum	N	Includes 7 smart classrooms,modern technology and beauty
Warren Wilson College	EcoDorm	Residence Hall	2003	9000	36	$1.5 million	$8769	$28540	Y	Y	Platinum	N	Key Features: solar electric and solar thermal energy generation; composting toilets; rainwater reclamation
Grand Valley State University	2010 Housing Project	Residence Hall	2010	279974	600	N/A	$8480	$10078	Y	Y	Gold	N	Key Features: Energy-efficient lighting, heating and air conditioning systems; landscaping that requires minimal irrigation with expansive storm water management systems; and special paints that minimize release of hazardous by-products.
Allegheny College	North Village II	Residence Hall	2010	N/A	230	N/A	$5300	$37260	Y	Y	Gold	N	The building's sustainable strategies and features include Forest Stewardship Council-certified wood; construction materials with high recycled content and produced within 500 miles of the site; open spaces with vegetation to reduce rainwater runoff; an energy-efficient heating and cooling system fed by on-site geothermal wells; the presence of natural light in living spaces; efficient showerheads, faucets and toilets; and energy-saving motors in all mechanical equipment
Appalachian State University	Frank Hall	Residence Hall	2009	N/A	203	$6 Million	$2150	$9168.5	Y	Y	Gold	N	solar panels, low-flow shower and sink fixtures, recycled and reused lobby furniture, water-source heat pumps in each room, and dual flush toilet valves.
Appalachian State University	Mountaineer Residence Hall	Residence Hall	2011	97000	460	N/A	$2300	$9168.5	Y	Y	Gold	N	Energy efficient lighting with motion sensors, low-flow shower heads and toilets, and a 40 panel solar thermal system.
Berry College	Audrey B. Morgan and Deerfield Hall	Residence Hall	2009	N/A	350	N/A	$8344	$27450	Y	Y	Gold	N	low-flow showerheads, faucets and washers; motion sensor lights and thermostats; and LED lighting fixtures.
California Polytechnic State University	Poly Canyon Village	On-Campus Apartments	2008	N/A	2700	N/A	$7438	$8742	Y	Y	Gold	N	low volatile organic compounds material, reduction of water use, water-efficient landscaping, use of recycled content, and 90 percent diversion from the landfill of construction waste
Carleton College	Cassat Hall and Memorial Hall	Residence Hall	2009	91536	230	27.5 Million	$8069	$44184	Y	Y	Gold	N	landscape designed with native vegetation, parking lots with porous paving, storage room with space for securing bicycles, high efficiency lighting, a solar thermal hot water system, and a radiant in-floor heating system.
Dickenson College	Centre for Sustainability Living- Treehouse	Sustainable House	2006	N/A	14	N/A	$11178	44551	Y	Y	Gold	N	Sustainable-minded individuals. Renovavated with recycled materials.
Harvard University	Graduate Green Housing Complex	Housing Complex	2008	115000	215	N/A	$10800	$53500	Y	Y	Gold	N	bamboo flooring; low-VOC finishes on walls and flooring
Massachusetts Institute of Technology	Ashdown House	Residence Hall	2006	279000	541	N/A	$12188	$42050	Y	N	Gold	N	The building's landscaping and irrigation systems use water from a non-potable source; a storm-water management system significantly reduces storm-water runoff; maximized daylight is available in 95 percent of regularly occupied spaces; and low-flow fixtures reduce water use by more than 20 percent
Ferris State University	East Campus Suites	Residence Hall/Alternative Apartment	2012	N/A	300	N/A	$5958-7335	$10710	Y	Y	Gold	N	30% reduction in water consumption; 18% reduction in energy consumption; storage of 175,000 gallons of water below parking lot to allow absorption and slow discharge; diversion of more than 90% of construction waste from local landfills; incorporation of high-efficiency glass and spray-applied insulation to maximize efficiency of the buildings envelope
Hawaii Preparatory Academy	Energy Lab	Student Lab Space	2010	6112	N/A	4.5 million	N/A	$22300	N	N	Platinum	Y	Living Building Challenge, Water Catchment, Wind&Solar energy, change the future paradigm of sustainability
Elon University	Loy Center	Greek Life Housing	2011	6x4500	218	N/A	$6077	$30149	Y	Y	Platinum	N	adaptive vegetation; high-efficiency plumbing fixtures; stormwater management
Western Oregon University	Ackerman Hall	Residence Hall	2010	91000	330	16 million	$7095	$2843	N	N	Platinum	N	cut its electricity use by 35 percent and produced water savings of nearly 75 percent that of a comparable building of its size. The facility includes a rainwater harvest system that collects rainwater used for flushing toilets, solar panels and heat ducts that heat air and water, occupancy sensors that shut off lights in unoccupied rooms, and low-flow water devices in all restrooms
University of Arizona	Arbol de la Vida	Residence Hall	2011	335284	719	N/A	$7450	$9114	N	Y	Platinum	N	75% of hot water is powered by roof mounted solar pannels, smart thermostats, low flow toilets, faucets, showerheads, passive water harvesting, storm water mitigation, drought tolerant plants, landscaping to conserve water, large windows for ventilation, dual window shades for light and darkness, computer designed awnings, an interactive "Building Dashboard"-lets student's monitor hall's energy and water usage, student rooms, study rooms, lounge areas, community bathrooms.
James Madison University	Wayland Hall	Residence Hall	2011	41000	80	11.5 million	$8288	$8808	Y	Y	Platinum	N	renovation ties innovative design strategies such as ground source heat exchange (geothermal heating and cooling) and rainwater harvesting to the university's standard building systems. the building is now on track to achieve 39% energy savings, 68% water savings
Plymouth State University	Langdon Woods Housing Complex	Residence Hall	2006	114000	347	29 million	$8100	$10410	Y	Y	Gold	N	58% more energy efficient 36% less water use 77% recycled construction waste 20% recycled materials used 40% of all materials manufactured within 500 miles 50-year stormwater capacity 69% FSC certified wood
University of Notre Dame	Ryan Hall	Residence Hall	2009	74000	248	N/A	$12512	$44605	Y	N	Gold	N	Thirty-nine percent of all building materials were extracted and manufactured within a 500-mile radius from campus. Ninety-one percent of the spaces in the building have natural daylight and exterior views. The building uses low flow urinals, faucets, shower heads, and dual-flush, low-flow toilets for water savings which produce a total water savings per year of 32 percent
Unity College	TerraHouse	Student House	2011	2186	10	N/A	$8714	$23000	Y	Y	(Passive House Certified)	N	designed to use about 186 Btu per hour, compared to the 11,000 Btu per hour a normal. The building has huge two-story windows situated so that they get the maximum sunlight in the winter. The roof overhang is designed so that the solar gain is much less in the summer, as one of the biggest challenges of the passive solar design is that the building could get too hot in the summer

Willamette University	Kaneko Commons	Residence Hall	2007	64000	151	17.5 million	$9820	$40560	Y	N	Gold	N	Water source heat pumps, rainwater reclamation reservoir and solar hot water heating; photovoltaic panels to serve as shading devices for residential units and the atrium
Saint Xavier University	Arthur Rubloff Hal	Residence Hall	2006	37084	88	9.5 million	$19800	$54600	N	N	Gold	N	700 sqft intensive green roof, 1 rain garden, Northern European sidewal displacement ventilation in all common areas, dual flush toilets
California State University, Fullerton	Fullerton Student Housing Phase III	Residence Hall	2011	347899	1064	143 million	$9042	$23520	N	Y	Platinum	N	4 pipe central plant HVAC system, Bioswales for storm water management, low water use irrigation and plant selection, low flow plumbing fixtures, high energy efficient glass and window systems, emergy management systems, high efficiency lighting and lighting controls, LED outdoor lighting, sunshades, discriminate building orientation on site, recycling of existing site paving and concrete materials on site, enhanced commissioning
Pomona College	Sontag and Pomona Halls	Residence Halls	2011	78000 (combined)	153	53 million	$3938	$20580	Y	N	Platinum	N	a 2,000 gallon solar hot water system predicted to provide 80% of the buildings' needs, rooftop solar voltaic panels providing 80 kw of power (an estimated 14% of the building load), a storm water management system, with a detention basin to recharge the aquifer, providing 100% decrease in runoff, 170 underground parking spaces removing the heat island effect associated with above-ground parking, rooftop garden, removal and replanting of eight mature oak trees on site, drought-resistant native landscaping
University of Bradford, U.K.	"The Green"	Residence Hall, sustainable village	2011	N/A	1026	63 million	Cluster flat: 4062.24 pounds Townhouse: 3737.16 pounds	$9000	N	N	Highest BREEAM rating	N	Energy usage monitors, solar-powered water heaters, extra insulation for heat retention, rainwater ponds, recycling facilities, sustainably-harvested timber, low-energy fittings, and low-flow plumbing fixtures, among other features. Even better, it's designed to promote community among the students, offering great outdoor garden spaces around the building.
University of New Hampshire	Mini Dorm "Hall House"	Environmentally themed House within a hall	1974	N/A	50	N/A	$3414	$13670 (year)	Y	Y		N	Just an interesting concept.
Duke University	Home Depot Smart Home	Residence Hall/Laboratory	2007	6000	10	2 million	$6630	$41938	N	Y	Platinum	N	Plants on roof, HVAC Systems, solar panels to direct electricity, 350 gallon rain water harvesting, fiber optic network, solar hot water. (See Link)
University of Washington	Poplar Hall	Residence Hall	2011	N/A	270	180 million	$2664 (quarter)	$28056	N	Y	Gold	N	computer screens that monitor energy usage, heat recovery system for energy efficiency, variant refrigerant flow heating, venting and air conditioning for lower floors thermostats in rooms to allow students to control heat in their room, but which sets the temperature lower when the space is unoccupied, most lighting and appliances that meet EnergStar standards
North Carolina Central University	Chidley North Residence Hall	Residence Hall	2011	134000	517	24 million	$3,000-3,200	$5478	N	Y	Gold	N	ICF (insulated concrete form) bearing-wall assembly, an energy recovery system, and an aluminum sunshade assembly. energy recovery system pre-treats outside ventilation air by recovering the embodied energy in the exhaust air. It reduces the difference between the outside and inside air temperatures and humidity levels by 50 percent. In addition, a high-efficiency chilled water plant in the basement provides cooling at a lower cost.
Holy Cross	Figge Hall	Residence Hall	2011	60000	156 seniors	19.2 million	$7800	$41468	N	Y	Gold	N	Low-flow fixtures, Occupancy sensors, Large windows allow for ample natural light, reducing the need for artificial lighting loads. The heating and cooling system includes condensing boilers with efficiency greater than 90 percent. Each unit has an enthalpy wheel that allows you to preheat or pre cool the outdoor air used for ventilation with building exhaust air. Low-emitting carpets, paints, adhesives, and furnishings contribute to protecting the indoor air quality. Additionally, a green housekeeping program has been established that reduces waste, improves indoor air quality, and protects the environment from harmful cleaning chemicals. Regionally sourced and recycled content materials include many of the structural components of the building. Structural steel contains almost all recycled content at 99 percent, the curtain wall has more than 65 percent recycled content, the windows have more than 5 percent recycled content and the concrete is harvested locally in Massachusetts. The residence hall contains a secure interior bike storage room to encourage students to use an alternate means of transportation.
Vanderbilt University	The Commons Center: Crawford/Sutherland Houses	Residence Hall	2007	175000	150	40 million	$13818	$42118	Y	N	Gold	N	Low flow and waterless fixtures, state of the art HVAC systems, flooring made of bamboo (a resource that renews quickly), high efficiency kitchen exhaust systems, natural lighting in atriums and stairwells, motorized window shades to reduce heat and glare, and pervious concrete pavement which absorbs water rather than creates runoff. Most of the new materials being used in Commons structures have come from vendors located within a 500-mile radius of Nashville in order to conserve energy.
Emory University	Few and Evans Residence Hall	Residence Hall	2008	111000	292	Unknown	$2680-3930	$41164	Y	N	Gold	N	All of the paints and sealants used were low VOC (volatile organic compound). There are recycling rooms on each floor These halls were built in compliance with Emory's No Net Loss of Forest Canopy Policy. It is a five-story stucco building with marble accents and includes a low solar reflective index (SRI) red tile roof and keeps with the vernacular of the original campus design. A low SRI means that less heat is absorbed through the roof so the building is easier to cool. (See link)
George Washington University	South Hall	Residence Hall	2009	N/A	474	N/A	$10530	$45735	Y	Y	Gold	N	Energy Star white roof; low-VOC paints; fuel efficient vehicle parking; bike storage
Mount Holyoke College	Residence Hall	Residence Hall	2008	72000	176	30 million	$12140	$41456	Y	N	Gold	N	Solar panels and energy monitoring system
Green Mountain College	Sage Hall	Residence Hall	2010	N/A	26	N/A	$10948	$29620	Y	Y	Gold	N	renovated current building, low-VOC flooring and furniture; low-flow bathroom fixtures
Syracuse University	Ernie Davis Hall	Residence Hall	2009	124000	250	56 million	$13254	$37668	Y	Y	Gold	N	low-flow faucets and showerheads, efficient lighting, stormwater management system
New Mexico State University	Chamisa Village II	Apartments	2012	N/A	N/A	N/A	$2849	$3020.4	Y	Y	Gold	N	N/A
Pacific University	Berglund/Gilbert Hall	Residence Hall	2008/ 2009	N/A	N/A	N/A	$8992	$35260	Y	Y	Gold	N	Water use for irrigation is reduced 61.4% from standard designs, potable water waste is reduced by 92.5%, the project diverted 1,057 tons or 82.92% of onsite generated construction materials from landfills.

University of South Carolina	Honors Hall	Residence Hall	2009	191000	537	47.6 million	$7,000 (year) - building specific	$10488	Y	Y	Gold	N	features three classrooms, an academic advising office, faculty offices and the Honeycomb Cafe. It also has a storm water detention system to prevent large rain events from overwhelming the city system during heavy thunderstorms
Worcester Polytechnic Institute	East Hall	Residence Hall	2008	N/A	232	N/A	$8,726 (year) - building specific rate	$40,790 (year)	Y	Y	Gold	N	living green roof has approximately 5,000 square feet of sedum, chives, and other plants. Bike storage & Gym facilities.
University of New Haven	Soundview Hall	Residence Hall	2010	N/A	N/A	43 million	$4,900 (year) - building specific rate	$15,750 (year)	Y	Y	Gold	N	individual temperature control to each suite. Low-flow plumbing, passive solar design, drought resistant plants and grasses, and stormwater management.
Goshen College	Rieth Village	Housing, offices and classrooms	2006	N/A	32	2 million	$2,375 (semester)	$14,250 (year)	Y	Y	Platinum	N	onsite wind and solar thermal energy systems; onsite wetland-based waste water treatment; rainwater reclamation; ground source heat pumps.Contains classrooms and offices
Pitzer College	P.A.S.	Residence Hall	2007	N/A	318	N/A	$9,110 (year)	$43136	Y	Y	Gold	N	photovoltaic roof panels; water efficient landscaping
State University of New York College of Environmental Science and Forestry	Centennial Hall	Residence Hall	2011	138200	452	31 million	$7,500 (year)	$5570	Y	Y	Gold	N	minimizes maintenance and provides a pedestrian-friendly setting; limited automobile parking; indoor storage and cleaning facility for residents' bicycles
Texas Christian University	Sherley Hall	Residence Hall	2009	78403	315	16 million	34,500 (year)	6550	Y	Y	Gold	N	geothermal heating and cooling system, reuse of 75% of the original building, locally sourced materials, and reduced water consumption both inside the building thanks to low-flow fixtures and a 50% reduction in water used outside for irrigation.
Towson University	West Village Commons	Residence Hall	2011	85000	651	N/A	$2955 a term (multple occupants)	$2915 (term)	Y	Y	Gold	N	stormwater management plan. reduce energy by 24 to 50 percent, water use by 40 percent and solid waste by 70 percent.
University of Arkansas at Little Rock	West Hall	Residence Hall	2011	104000	370	23 million	$2985 per semester	$5910	Y	Y	Gold	N	educing potable water usage for irrigation by more than 52 percent. HVAC system designed to maximize energy performance, resulting in a 32 percent reduction in energy
Wheelock College	Campus Center	Campus Center/Residence Hall	2009	60000	108	24 million	N/A	$30055	Y	Y	Gold	N	green rook, recycled content, occupancy sensors/lighting control, low flow toilet fixtures, oversized windows, carpet tile, steel recycled content, long life light bulbs, FSC Certified wood, trayless dining, locally sourced materials
University of Minnesota Morris	Green Prairie Living	Residence Hall	2013	N/A	72	25 million	$11,720 (year)	$3,460 (double occupancy	N	Y	Gold	N	Residents that are civically engaged and effective stewards of their environment.
Harvard University	Hamilton Hall	Residence Hall	2006	48000	72	unknown	$40,016 (year)	$15,050 (single occupancy	Y	Y	Gold	N	Groundwater recharge drywells 38% reduction in domestic water use Efficient irrigation system tied to weather station
University of Arizona	Likins Hall	Residence Hall	2011	N/A	389	Unknown	$10,550 (year)	$7,560 (year)	Y	Y	Platinum	N	When student rooms are unoccupied, "smart thermostats" adjust the temperature, occupancy sensors turn off
Berea College	Deep Green Residence Hall	Residence Hall	2013	41759	121	12 million	$24100	$8948	Y	Y	Platinum	N	Thirteen percent of the building's power will be generated by a 40kW photovoltaic array on the roof. Water consumption will be monitored by students who have expressed a desire to participate in use-reduction competitions
University of South Carolina	Patterson Hall	Residence Hall	Renovated 2011	N/A	544	N/A	$10488	$5702	Y	Y	Silver	N	N/A
UC Davis	West Village	student/faculty/com living	2011	130 acres	4200	280 million	N/A	$32168	Y	Y	Zero Net Energy	N	Energy efficient design, photvolatic solar panels, waste to energy biodigester, bicycle and bus transportation, streets oriented to maximize solar passive design, on-site drainage.
University Colorado Boulder	Arnett Hall	Residence Hall	2008	63064	203	12.96 million	$5,500 - 7,000	$9664	Y	Y	Gold	N	sensors that suspend heating and cooling systems when windows are open, aerators on faucets, recycled materials for site
University California Berkeley	Clark Kerr Campus	Residence Hall	Renovation 2009	N/A	542	6 million	$15,000-18,000	$7492 (semester)	Y	Y	Gold	N	water efficient fixtures, low VOC materials, only energy star appliances, bike storage rooms, green keeping program, diversion of 75% waste from landfill, recycling rooms
University of Colorado Boulder	Andrews Hall	Residence Hall	Renovation 2009	N/A	200	N/A	$5,500 - 7,000	$9664	Y	Y	Gold	N/A	Key Features: double-pane windows, sensors that suspend heating and cooling systems when windows are open, dual-flush toilets, low-flow showerheads, aerators on faucets, energy-efficient lighting with automatic controls, and carpet and other finishes made from recycled materials.