Implementing an Electrical Retrofit at the Institute of American Indian Arts

An Interactive Qualifying Project
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ABSTRACT

Having made a strong commitment to reducing its contribution to global climate change, Santa Fe's Institute of American Indian Arts faces the challenge of implementing its 2050 Climate Action Plan. Our group collaborated with key staff members to plan and install a system of electrical metering for their campus and to implement low-risk, cost-effective building retrofits, such as LED replacements for their current lighting. Having taken these steps, and equipped with analytical tools developed by the project team, the IAIA is now well-positioned to systematically reduce electricity use, costs and carbon emissions across the campus.

EXECUTIVE SUMMARY

As the world's population has expanded and industrialization across the globe has grown, so have the negative effects of these triumphs of civilization. Global warming and climate change are real, worrisome problems that we must fix in order for our planet and our way of life to survive. Excessive carbon emissions from technology, machinery, and buildings have drastically exacerbated the threat and severity of global warming. These excess emissions have inspired a correct response in modern society, to become 'carbon neutral,' or, in other words, to achieve a net zero greenhouse gas impact (GHG) on the environment (Walenta, 2015). Governments (and non-state actors) around the globe now embrace the ultimate goal of carbon neutrality (Natural Capital Partners, 2015).

In order to properly combat climate change, we, as people, must adapt and change the way we view these issues, and acknowledge how our lives affect the environment we live in. As we design new buildings, we are able to accommodate the ambition to achieve carbon neutrality. However, the question of how to fix older buildings' emission levels remains. Many organizations and companies have invested in a process of retrofitting buildings, in order to deal with this dilemma. The campus of the Institute of American Indian Arts (IAIA) is fairly new compared to the European settlement of Santa Fe, which is 406 years old. Since the new campus was officially opened in August 2000, the IAIA has added new buildings that are more energy-efficient and sustainable in accordance with their Climate Action Plan, but their older buildings, unsurprisingly, fall short of the energy requirements now imposed due to their age and the technology that was available at the time. In order to initiate the first steps of this retrofitting process, our team was tasked with assisting the IAIA in implementing electrical retrofits and providing recommendations for future work.

Project Goal

The goal of this project was to help the IAIA implement its 2050 Climate Action Plan and thereby further reduce the carbon footprint of the institution. The team identified solutions to help reduce the usage of electrical utilities while also preparing recommendations for future projects.

Methodology

While doing project work, our team set forth three ways of approaching our overarching goal.

1. Identify and implement an affordable electrical metering system to assist the IAIA in beginning the measurement & verification process at their campus.
2. Research and recommend low-risk, cost-effective electrical retrofits, such as LED replacement bulbs, that the IAIA can implement to reduce electrical costs and greenhouse gas emissions.
3. Provide recommendations for the IAIA to continue project work that advances their Climate Action Plan.

Prior to arrival in Santa Fe, the team explored industry and expert guides on the process of retrofitting to better understand the approach to take during a project of this nature. When we began our project work, Mr. Mason assisted us in narrowing our tasks to beginning the process of

measurement & verification at the IAIA, replacing inefficient lighting, and providing recommendations on future work. The team contacted several companies that provided electrical meters after researching their specific features to find the best fit for the IAIA's needs. Distributors in the Albuquerque-Santa Fe area were then contacted to establish a relationship and purchase initial metering.

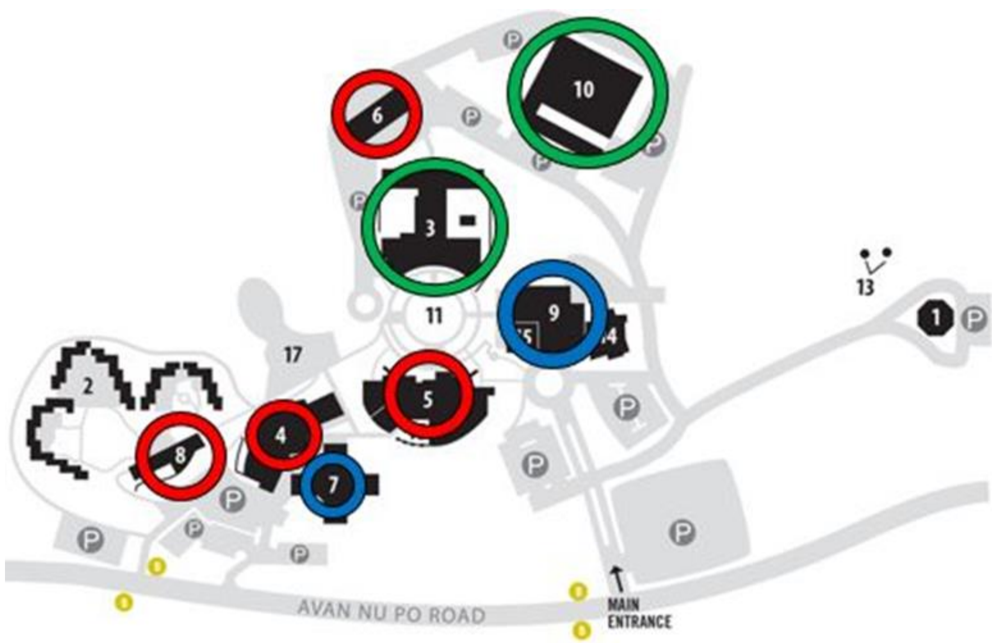
In advancing the lighting aspect of this project, the team created a tool for inventory and analysis of the current lighting on the IAIA's campus. This tool is intended to assist in calculating cost savings as well as documenting changes in lighting as the IAIA takes steps towards more efficient lighting solutions. Because of the artistic nature of the classrooms at the IAIA, the team placed high importance on retaining the integrity of the lighting when assessing bulb replacement options. The team also spoke with distributors in the area to obtain a rough cost estimate for an initial purchase of bulbs for the IAIA to test different options.

Finally, the team combined lessons learned from the expert guides we utilized initially with this project's outcomes to create a set of recommendations for near future project work at the IAIA.

Results and Analysis

From our communications with metering distributors, the team came to a consensus on a metering brand, Leviton, that filled our sponsor's needs at an affordable price. The resulting relationship that was established with a local distributor, Dealers Electric, led to these plans for electrical metering for the IAIA's entire campus:

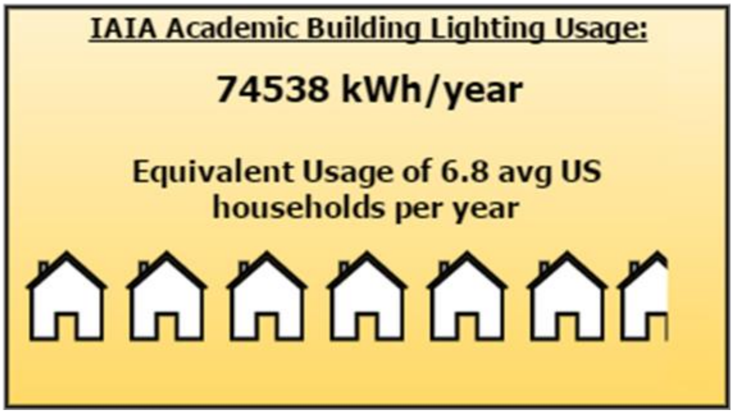
- immediate installation of metering systems in the Academic Building and Foundry building
- a quote for metering in the Science & Technology Building and the Residence Center
- a bill of materials for the four remaining buildings without metering – Library, Wellness & Fitness Center, Center for Lifelong Education, and Facilities



Metering outcome from project work

To increase energy savings while still maintaining illuminance levels, we decided to:

- Inventory the Academic Building and calculate the cost to operate current lighting through an analytical tool the team created, the Lighting Inventory & Analysis Spreadsheet (LIS)
- Research different types of LED replacement bulbs to determine the safest and most cost-effective option for our sponsor
- Measure illuminance levels to ensure that the current levels could be maintained with LED lighting



Data found from calculations in the LIS

Recommendations

To form our recommendations, the team integrated our own project work into consideration with the industry guides that helped structure our work. These two factors led to six specific recommendations:

1. The IAIA should have an energy audit done on the buildings they intend to retrofit further.
2. The IAIA should utilize data from the metering system in planning event and academic scheduling.
3. The IAIA should develop a systematic approach to future retrofitting projects that aligns with the goals they wish to achieve through their Climate Action Plan.
4. The IAIA should consider other devices that reduce gas and water usage.
5. The IAIA should establish a revolving fund and explore other options to finance retrofit projects.
6. Students enrolled in the sustainability class at the IAIA should aid in data collection.

Conclusion

The project work undertaken at the IAIA will allow our sponsor to begin reducing its carbon emissions, as set forth in its Climate Action Plan. The decisions the team made reflect the needs of the IAIA as well as the limitations we faced.

The team's recommendations were developed with our awareness of how the IAIA currently conducts retrofits renovations as well as the knowledge that a WPI project group would be following up on our work in the fall of 2016. The recommendations reflect the direction that the

IAIA wants to move forward in accordance with their Climate Action Plan. What we have proposed will allow the IAIA plan renovations efficiently for years to come. Additional information can be found online at https://sites.google.com/site/sf16diaia/.

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CHAPTER 1: INTRODUCTION

As the world's population has expanded and industrialization across the globe has grown, so have the negative effects of these triumphs of civilization. Global warming and climate change are real, worrisome problems that we must fix in order for our planet and our way of life to survive. Excessive carbon emissions from technology, machinery, and buildings have drastically exacerbated the threat and severity of global warming. These excess emissions have inspired a movement in modern society to react against the trend, to become 'carbon neutral,' or, in other words, to achieve a net zero greenhouse gas impact (GHG) on the environment (Walenta, 2015). Governments (and non-state actors) around the globe now embrace the ultimate goal of carbon neutrality (Natural Capital Partners, 2015).

In order to properly combat climate change, we, as people, must adapt and change the way we view these issues, and acknowledge how our lives affect the environment we live in. As we design new buildings, we are able to accommodate the ambition to achieve carbon neutrality. However, the question of how to fix older buildings' emission levels remains. Many organizations and companies have invested in a process of retrofitting buildings, in order to deal with this dilemma. The campus of the Institute of American Indian Arts (IAIA) is fairly new compared to the European settlement of Santa Fe, which is 406 years old. Since the new campus was officially opened in August 2000, the IAIA has added new buildings that are more energy-efficient and sustainable in accordance with their Climate Action Plan, but their older buildings, unsurprisingly, fall short of the energy requirements now imposed due to their age and the technology that was available at the time.

Previous research efforts include a 2014 IQP that worked on updating another building on the IAIA's campus. This project resulted in several recommendations for the building. It also explored solar feasibility on the campus beyond that one building. These efforts were prompted by the school's Climate Action Plan, which calls for the carbon neutrality of their campus by the year 2050. The President of the school committed to this effort in 2010, and the Climate Action Plan itself was published in 2013 with the steps and goals necessary to reach this ultimate goal in a timely manner. The Climate Action Plan, and the subsequent measurements that we found through previous project work, have allowed us to access data on the carbon baselines during these years. This data helped us discover how we should approach our implementation and recommendations in order to reduce their carbon emissions.

Despite this initiative, the IAIA's carbon use has increased since the signing of the climate action commitment. It turns out to be quite challenging to achieve substantial carbon footprint reductions, even when an institution has all the best intentions of doing so, due to a number of factors. Most importantly, the IAIA lacked an in-depth plan for implementation over a long period, which is essential to the success of any ambition of this magnitude. Their Climate Action Plan lists the steps and goals, but does not have an actual systematic approach that can be followed. The school's population has also risen in the years since the original baseline measurements were done, and since there has not been any significant action in the ensuing years, the carbon baseline usage has risen. The last factor that has contributed to this inaction is a lack of funding. Projects of these nature often come with a very hefty price tag, and as a small, indigenous, non-profit college, IAIA often has to look to other sources than their own income and investments to fund these kinds of initiatives. While our project was primarily able to be funded through the IAIA's budget, a number of our recommendations were provided due to a lack of extraneous funds for larger-scale projects.

The purpose of our project was to help the IAIA implement its 2050 Climate Action Plan and to further reduce the carbon footprint of the institution. While we were not able to develop a fully comprehensive outline due to decisions that were made between ourselves and our sponsor, as well as a relatively short timeframe, we were still able to begin taking action steps towards optimal building efficiency as outlined by several industry guides. Our project deliverables provide solutions for two key aspects of retrofitting: the measurement and verification process and the process of installing shallow retrofits. In addition to these deliverables, the team was able to provide the IAIA with recommendations for future work.

CHAPTER 2: BACKGROUND

Environmentally-friendly organizations like the IAIA can counteract global climate change by making wise choices in the renovation of existing commercial, academic, and residential buildings. This goal of carbon neutrality can be achieved over time in ways that save on energy costs in the meanwhile.

Our background research focused on four main topics. We first looked at the IAIA itself, along with its unique worldview that helps to set our project apart from a standard renovation. Our next section examines its Climate Action Plan, which is the document guiding the school's efforts to attain carbon neutral status. The next point of research is sustainability and the reasons that it is so vital to taking steps toward carbon neutrality. We then discuss the main process we intend to use to develop steps to this plan, which is retrofitting the building we are working on with more sustainable and green technology.

2.1 Institute of American Indian Arts

The Institute of American Indian Arts is a unique school for many reasons. Founded in 1962 by President John F. Kennedy, the IAIA is one of 37 tribal colleges in the United States. According to the information provided on their website, the IAIA is the only school solely dedicated to the pursuit and development of contemporary Native American art, and is the only multi-tribal arts school in the country. As previously mentioned above, the IAIA's campus is relatively new, and is situated away from the heart of Santa Fe and significantly more rural. **Figure 1** provides a Google map comparison of the location of the IAIA with relation to what is considered the center of Santa Fe.

According to Mr. James Mason, our sponsor liaison, their campus is very quiet and picturesque. He has said that "it's the type of place that people go to escape and think, where the skies are so blue and the air is so clean" (Mason, 2016). The IAIA is well loved by the people who inhabit it, so it is important that they keep their campus sustainable not only for aesthetic reasons, but also because sustainability is fundamentally important to them because of their tribal values. These tribal values are documented in the Climate Action Plan, which launched the IAIA's sustainability efforts. This section will look at the institution and its demographics, as well as the reasons why the movement to become sustainable is so important to them not only for impact reasons.

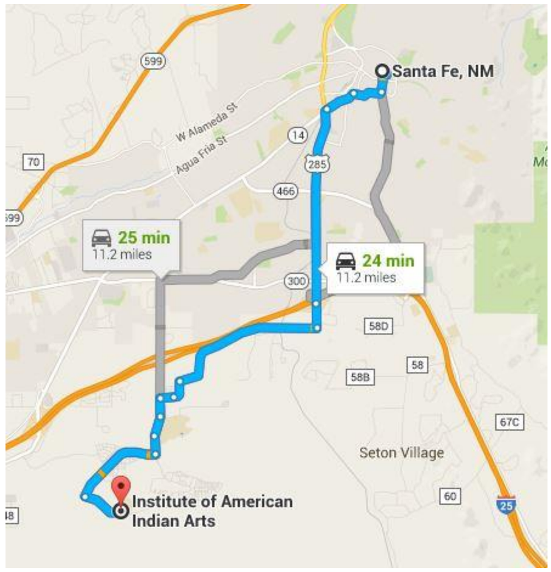

Figure 1: The IAIA's location compared to the center of Santa Fe

2.1.1. The IAIA and its Demographics

The IAIA is a tribal college that focuses on Native American art and is located in Santa Fe, New Mexico. It is the only national center of research, training, and scholarship for Native Americans devoted solely to American Indian and Alaska Native arts and culture (Institute of American Indian Arts, 2016). Graduates from the IAIA often transition into full-time careers as artists, while others pursue continued education at universities and art schools across the nation. The IAIA also employs many alumni as full-time faculty and staff, while they also pursue their artistic goals (Mason, 2016). The Museum of Contemporary Native Arts is operated by the IAIA (**Figure 2**). The museum is located in the old Post Office in Santa Fe, which is a pueblo revival building listed on the National Register of Historic Places. The building holds the National Collection of Contemporary Indian Art, which contains more than 7,000 pieces.

Figure 2: Museum of Contemporary Native Arts

493 students attend the IAIA, with the full-time equivalent equalling 382 students (Institute of American Indian Arts, 2015). Among these, 137 reside in on-campus housing, with 107 in dorms and the other 30 students in family housing, which means that 356 of the students commute or attend online courses (Institute of American Indian Arts, 2015). The student population is broken down with 56% being female and 44% being male, 72% are American Indian /Alaska, and they have an average age of 27 years old (Institute of American Indian Arts, 2015). The students come from 34 different states, 77 federal tribes, and 3 foreign countries (Institute of American Indian Arts, 2015). IAIA has continued to have its student population increase year to year (**Figure 3**). The red line (Head count) represents the total number of students attending, while the blue line (Full Time Equivalent) represents the number of full time students.

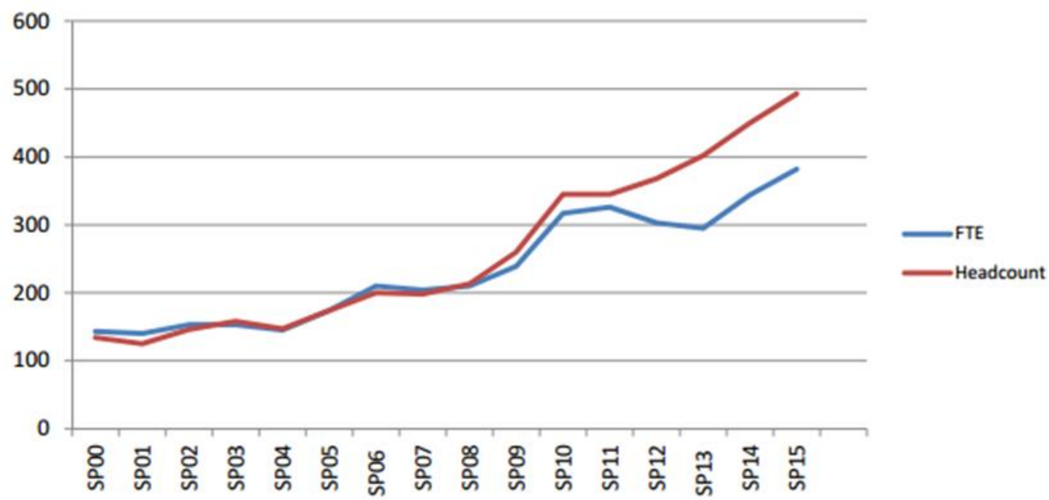

Figure 3: IAIA student enrollment

Students at the IAIA can obtain four different levels of education. The fields of study cluster mainly in the arts, but there is a business field that is only for the lowest level. Levels of degrees offered at the IAIA are as follows: Certificate Only, AA/AFA, BA/BFA, and MFA (Institute of American Indian Arts, 2015). The enrollment of students in each degree varies depending upon the major student of field and the degree level (**Table 1**).

Major Field of Study	Certificate Only	AA/AFA	BA/BFA	MFA
Museum Studies	6	1	16	
Creative Writing		3	11	53
Studio Arts		16	95	
Cinematic Arts/Technology		6	39	
New Media Arts (old plan)			2	
Native American Studies		4		
Indigenous Liberal Studies			22	
Certificate-Business/Entre. & Business Cert.w/a major	9 30			

Table 1: Degree enrollment statistics (2015)

2.1.2 The IAIA Charter

Originally founded as a high school during the Kennedy administration, this distinctive founding resulted in the IAIA charter, which places unique conditions and constraints on this project. As a university chartered by Congress, there are rules that our sponsor has to adhere to that a normal private university might not have to navigate.

Historically, there are fewer than ten colleges nationwide that operate under a Congressional charter. The IAIA is unique in that it has not developed into its own entity, but rather, it still operates under its Congressional charter and receives an annual budget from Congress each fiscal year. The rules of the charter exist under the U.S. code Title XX, chapter 56 entitled "American Indian, Alaska Native, and Native Hawaiian Culture and Art Development" (Institute of American Indian Arts, 2016). This charter lays out how the university should be set up in terms of its administrative logisitics, its tax-exempt status, and how it should operate as a traditionally Native institution. Due to the IAIA charter, certain exemptions and limitations govern institutional relationships with private companies, which can pose a unique challenge when undertaking renovation or new construction (Mason, 2016).

2.1.3. Sustainability and the IAIA

There are many reasons why becoming sustainable is an appealing option for academic campuses and businesses. Sustainability is not just an economic choice; it is also a moral choice. At the IAIA, the students are mainly descended from different Native American tribes, and they have been living off the land while also taking care of it for centuries. Their relationship with the environment is deeply entrenched in their culture as well as highly symbiotic. It is this sense of being sustainable that allows them to be so at home with nature, and why their reasoning for updating the building is more altruistic than it is about savings.

According to the school's Climate Action Plan published in 2013, sustainability is important to them due to the nature of how Native Americans have lived for hundreds of years. "Native communities have the longest sustainable cohabitation on the planet, and as indigenous cultures are still intimately connected to and dependent on the places where they live, many Native communities globally are on the front lines of climate crisis impacts." (Institute of American Indian Arts, 2013). Being of indigenous origins, the school has a deep relationship with the environment, and this is evident in how they want to update their campus and work on becoming carbon neutral.

Beyond the IAIA's individual actions, there has been in an increase in sustainability initiatives by different indigenous groups, as indigenous peoples across the globe have tried to make the effort to live off the land through renewable energy. Some examples of this effort towards sustainability can be seen through the implementation of self-sufficient indigenous communities. This movement has not been limited to actions through a Native community, however. In fact, some past IQP projects, such as a 2012 project entitled "Sustainability Education and Awareness for Santa Fe and Native American Communities", have helped foster these types of sustainability efforts. This project entailed the usage of complied educational resources, such as interactive websites, to help make the Native communities in the Santa Fe area more aware of sustainability and to help them become more involved in the process of making their communities and schools more sustainable (Jordan, et al., 2012).

The indigenous relationship with the environment is an important aspect of the project. This relationship is so vital to how our project operated because of the deep respect for the natural world that indigenous peoples have, as well as their commitment to living simply, often as their ancestors did for thousands of years.

2.2 Climate Action Plan

On September 30, 2010, the IAIA signed the American College and University Presidents Climate Commitment (ACUPCC) with the goal to become a carbon neutral campus. In 2013, the IAIA created their Climate Action Plan (CAP), which set the period to achieve a carbon neutral campus to by 2050. The CAP set a milestone to have a fifty percent reduction by 2025. At the IAIA, there are four main source of carbon emissions (**Figure 4**). The sources are electricity from Power New Mexico (PNM), natural gas, solid waste, and transportation, which resulted in the net emission of 2,335 metric tons of CO2e for the baseline year of 2010 (Institute of American Indian Arts, 2013).

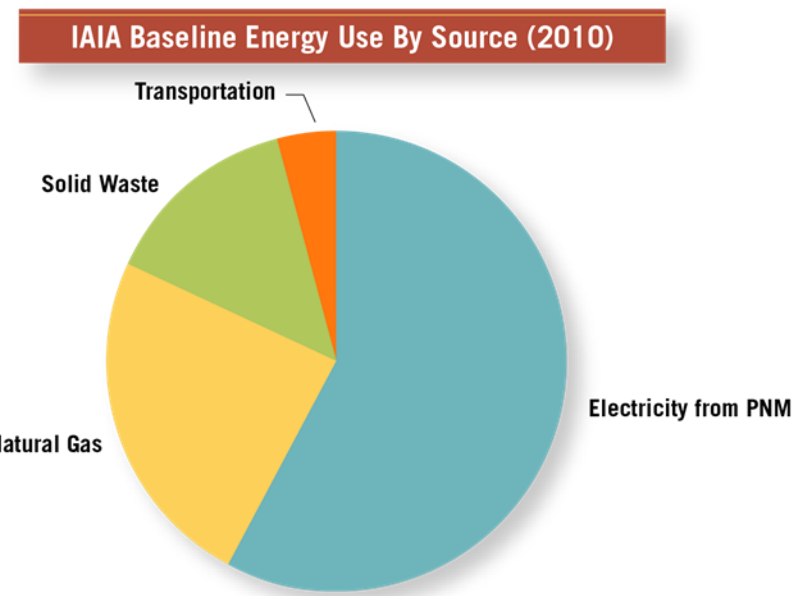

Figure 4: IAIA baseline energy usage (2010) (Institute of American Indian Arts, 2013)

2.2.1. American College & University President's Climate Commitment

In 2006, a group of colleges and university presidents from across the United States created the American College & University President's Climate Commitment (ACUPCC) to address global warm (Second Nature, 2016). This networks of colleges and universities are committed to neutralizing their emissions, and work on research and educational efforts in higher education. Although the ACUPCC started with only 12 colleges in 2006, by Earth Day of 2008 there were signatories in all 50 states and Washington D.C., making it truly a national initiative (Second Nature, 2016).

The ACUPCC started with the help of Second Nature, ecoAmerica, and the Association for Advancement of Sustainability in Higher Education (AASHE), who assisted in developing the Commitment (Second Nature, 2016). Second Nature became the sole supporting organization in 2011. Second Nature is a non-profit organization that was founded in 1993. Their mission is "to proactively build a sustainable and positive global future through initiating bold commitments, scaling successful actions, and accelerating innovative solutions among leadership networks in higher education" (Second Nature, 2016). Second Nature has developed a reporting system where all the signatories send in their Implementation Profile, GHG Reports, Climate Action Plans, and Progress Reports, which all can be obtain by the public through Second Nature's website (Second Nature, 2016).

2.2.2. Current Progress on the Climate Action Plan

The IAIA has not reported any information to Second Nature since the 2013 Climate Action Plan. The school previously submitted data on their yearly carbon usage in 2010. The next time they are expected to submit data is in January of 2017. Though there is no data in Second Nature's site, the 2014 WPI IQP "Monitoring and Planning the Reduction of Carbon Emissions at the Institute of American Indian Arts" worked to provide updated data. The 2014 report stated that the authors' utilized the Clean Air-Cool Planet Campus Carbon Calculator (CA-CP) to find their data (**Figure 5**), which gave the IAIA a carbon output of 2,946 metric tons of CO2e (Nutting, McMullen, Cornachini, Milholland, Mathews, Carrera, 2014). If the "Monitoring and Planning the Reduction of Carbon Emissions at the Institute of American Indian Arts" calculations are correct, then carbon output increased by 611 metric tons of CO2e, which is a 26 percent increase in carbon output since 2010. Such an increase in carbon emissions is excellent in terms of student enrollment, but does not further the CAP, which has a milestone of a 50% reduction in carbon emissions by 2025.

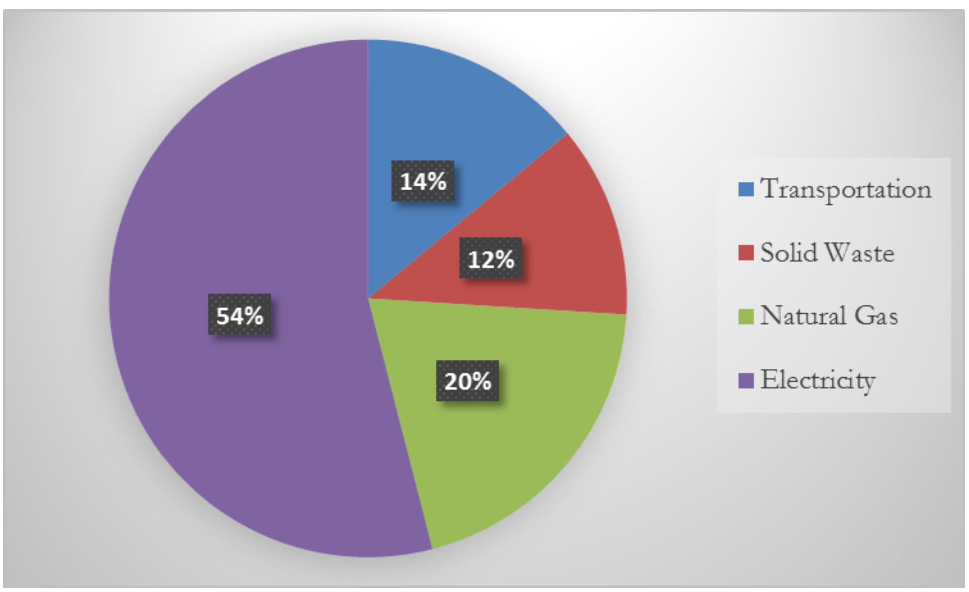

Figure 5: IAIA baseline energy usage (2014) (Nutting, et al., 2014)

The CAP states that the IAIA will implement the plan through its current decision-making structures and strategic planning process (Institute of American Indian Arts, 2013). According to this plan, "…a cabinet will be formed and will be given the responsibility of implementing the CAP, as they will propose annual sustainability projects" (Institute of American Indian Arts, 2013). The cabinet that the CAP envisioned is the Campus Climate Committee, which would ideally be comprised of between 11 and 20 members (Second Nature, 2015). Members on the committee would come from a set of diverse resources across the IAIA's campus. Some of the departments and groups ideally represented by this committee would include Essential Studies, Studio Arts, the president, Dean of Academics, CLE agriculture director, Dana Richards, student representative from the Associated Student Government, Facilities Director, and interested student leaders (Second Nature, 2015).

The current chair of the committee is Annie McDonnell of the Essential Studies department. Prior to our project work, the committee had not implemented many large-scale projects. James Mason, the Facilities Director, has been successful in starting projects such as replacing lighting with more efficient LED lighting. To gain a better sense of electrical usage at the IAIA, Mr. Mason asked the team to supply him with suggestions on electrical meters for individual buildings so that he can monitor the effects initial efforts may have already had on electricity usage.

2.2.3. Previous Interactive Qualifying Project Work

The IAIA has worked with multiple WPI IQP teams in the past on different projects. The last two projects were "Designing a Tribal Planning Certificate for the Institute of American Indian Arts" and "Monitoring and Reducing the Carbon Emissions of the Institute of American Indian Arts." Of these two projects, the 2014 project "Monitoring and Reducing the Carbon Emissions of the Institute of American Indian Arts" is the one that was relevant and useful to our project. The 2015 project focused more on creating a Tribal Planning and Community Development Certificate to assist the Native American tribes in New Mexico with new community planners.

"Monitoring and Reducing the Carbon Emissions of the Institute of American Indian Arts" has proven to be an invaluable wealth of information. The 2014 group was able to obtain electricity and gas bills for the IAIA, and transportation data from faculty and students, which was used to obtain an update carbon baseline for the campus. At the Center for Lifelong Education building, the group was able to create an inventory of electrical usage, which provided an example to our team on how to conduct such an inventory in a building at the IAIA. In the report, the previous group made suggestions for replacing lighting (**Table 2**), along with compiling how much the replacements would save the IAIA (Nutting, et al., 2014). The group provided equations for calculating the savings. The 2014 team also developed plans for implementing PV arrays around the IAIA campus, with rooftop, carport, and ground-mounted solar panels being considered as viable options (Nutting, et al., 2014). In the recommendation section of the report, the 2014 group points out while they were at the IAIA, there was no full-time leadership for sustainability (Nutting, et al., 2014). This observation led to the group recommending that the IAIA retain a dedicated sustainability coordinator on their staff (Nutting, et al., 2014).

	Type of Light	Watts	Lumens	Color	Life Expectancy	Cost
Currently used Tube	Fluorescent	32	2800	3500K	14 years	$2.79
Proposed Tube #1	LED	18	1850	3500K	19 years	$29.96
Proposed Tube #2	LED Easy Fit	22	2200	4100K	19 years	$34.99

Currently used Short Tube	Fluorescent	13	800	2700K	4 years	$1.75
Proposed Short Tube	LED	7	350	3200K	19 years	$105.26
Currently used Track Light	Incandescent Halogen Spot	20	150	2950K	4000 hours	$0.86
Proposed Track Light #1	LED: 20 W equi, spot	4	230	2700K	19 years	$20.93
Proposed Track Light #2	LED: 20 W equi, narrow	5	300	2700K	19 years	$25.00
Currently used Flood Light	Incandescent Halogen Indoor	35	390	2950K	2000 hours	$0.81
Proposed Flood Light #1	LED: 30 W equi, flood	7	315	2700K	12 years	$17.11
Proposed Flood Light #2	LED: 20 W equi, flood	3.5	250	3000K	12 years	$21.05

Table 2: Proposed LED lighting replacement (2014) (Nutting, et al., 2014)

2.3 Sustainability

Our planet has a radically different environment than the one that existed before the Industrial Revolution. While we can attribute some portion of that change to the Earth's natural tendency to change itself, it has mostly been brought about through our own actions. The introduction of different pollutants and the mass overpopulation of our planet has rapidly changed our resources and the climate we live in. Now, the entire globe is much more aware of the issues we face in lessening our energy and resource consumption, and as such, we have changed how we choose to go about using them. In today's world, being sustainable is incredibly important. Many benefits can be gained from making the effort to help prolong the life of our planet as we know it.

Sustainability is not only limited to the technical aspects of the movement, such as installing renewable energy sources or reducing utility usage. Sustainability is a rich, subjective topic that also is deeply invested in the economic and societal issues that arise within moving to combat climate change. These societal issues often arise over the use of land or water, and they should be considered heavily in the steps that should be taken when an institution of higher learning begins to try and become sustainable (Graedel, 2002). **Figure 6** demonstrates how sustainability is a complex issue that involves the influence of several factors beyond the environmental factors that are often the first argument for sustainability.

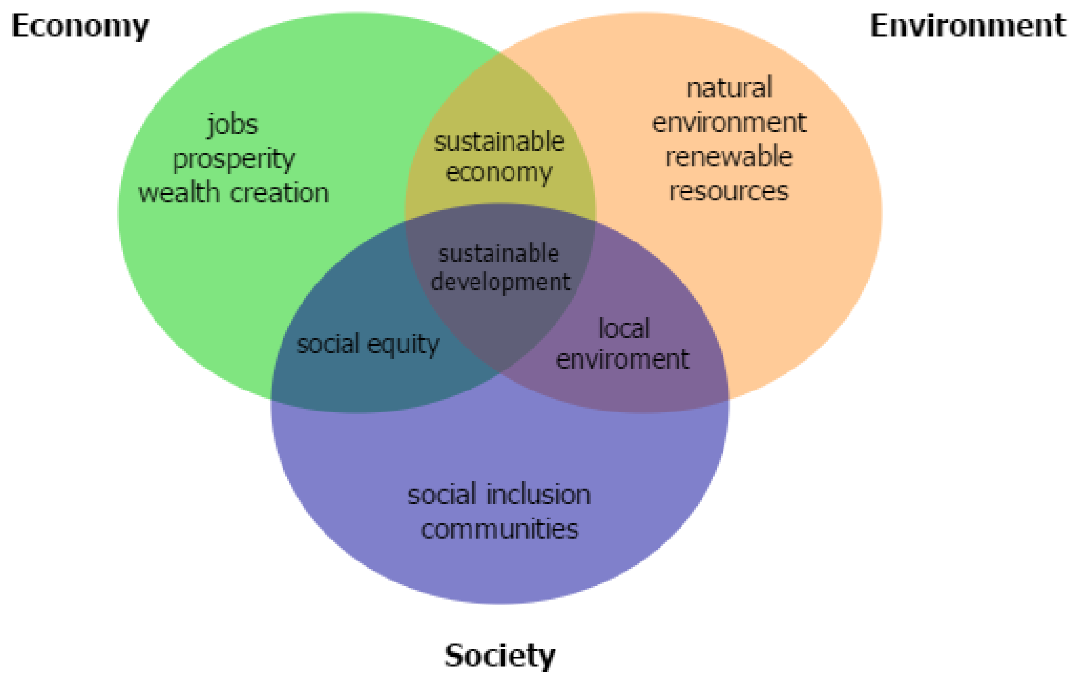

Figure 6: Factors that lead towards ideal sustainability

There are several organizations committed to sustainability, such as Clean-Air, Cool-Planet (CA-CP). These organizations serve as resources for those who want to make the commitment to sustainability. The world, in general, has taken the initiative to create a more sustainable world through government actions and the development of standards for new buildings. One such organization that helped to create a set of standards is the U.S. Green Building Council.

In 1993, the U.S. Green Building Council (USGBC) was established with the mission to promote sustainability in the building and construction industry. At the first meeting of the USGBC, which included companies and non-profit organizations, ideas surfaced that there should be a coalition spanning the entire building industry and a green building rating system. In March of 2000, the Leadership in Energy and Environmental Design (LEED) green building certification system was unveiled. The LEED system has since become one of the most widely recognized and used green building program across the globe, and is used to guide the design, construction, operations, and maintenance of buildings, homes, and communities. The LEED system has four levels of certification that projects may receive. A project could receive the following levels: certified, silver, gold, and platinum (U.S. Green Building Council, 2016). The certification level that a project gets depends on the number of points earned based off their updates or implementations (U.S. Green Building Council, 2016).

Initiatives likes these are what support making sustainability a commitment that people are able to follow up with in their everyday lives.

2.3.1. Sustainability Practices

Sustainability practices are some of the most efficient and reliable ways to make a building more environmentally friendly. These sustainability practices are not only limited to the installation of renewables such as solar panels or wind energy, but have a fundamental root in how we choose to utilize the resources and utilities we have in everyday life.

Several sustainability practices can be considered for any retrofit. For our particular project, the idea of an office building with college campus uses is considered in terms of what we can do when it comes to sustainable technology. Working with a college leaves us in a unique place in terms of what we can implement. Due to the nature of colleges being at the forefront of education and innovation, institutions of higher learning are more likely to implement a new or untested form of renewable energy (Graedel, 2002). In addition to this, since they are a place of education, they are more likely to remain stable as opposed to an organization or business, and this allows them to experiment in what they develop for sustainability (Graedel, 2002).

According to Graedel (2002), the truly sustainable materials that can be considered for energy use are fissile materials, renewable biomass, wind energy, solar energy, hydropower, geothermal power, ocean power, and materials that are currently considered unsustainable because they are finite resources, such as fossil fuels and natural gas. Fossil fuels in general are considered sustainable due to their usage, but because they are a natural resource that is limited by the amount that has been produced in the environment, they are not actually sustainable in the way that other materials are. They are also not sustainable due to the harm that their carbon emissions do to our planet's atmosphere.

Renewable energy sources are not the only way to commit to sustainability. Considering the scope of our project, renewable energy sources for the IAIA are in the future of their plans. Becoming more energy efficient before the addition of renewable energy sources is often highly desirable, because then the efficiency of your renewable implementations is at its peak performance. Being energy efficient in general is also a step in the right direction if you are committed to being sustainable, and there are benefits that go along with making energy efficient upgrades.

2.3.2. Being Energy Efficient

All sustainability practices add to a larger picture of being more energy efficient. Being energy efficient is defined as using less energy to yield the same amount of output or performance (Patterson, 1996). Energy efficient technology has come a long way since it became a priority for companies, organizations, and individuals alike.

Unless a building has been updated, it is generally not energy efficient, and there are many energy users in buildings in terms of utilities and technology. **Figure 7** displays the typical breakdown of how energy is used in an office-like building, similar to the one we will be working on in Santa Fe.

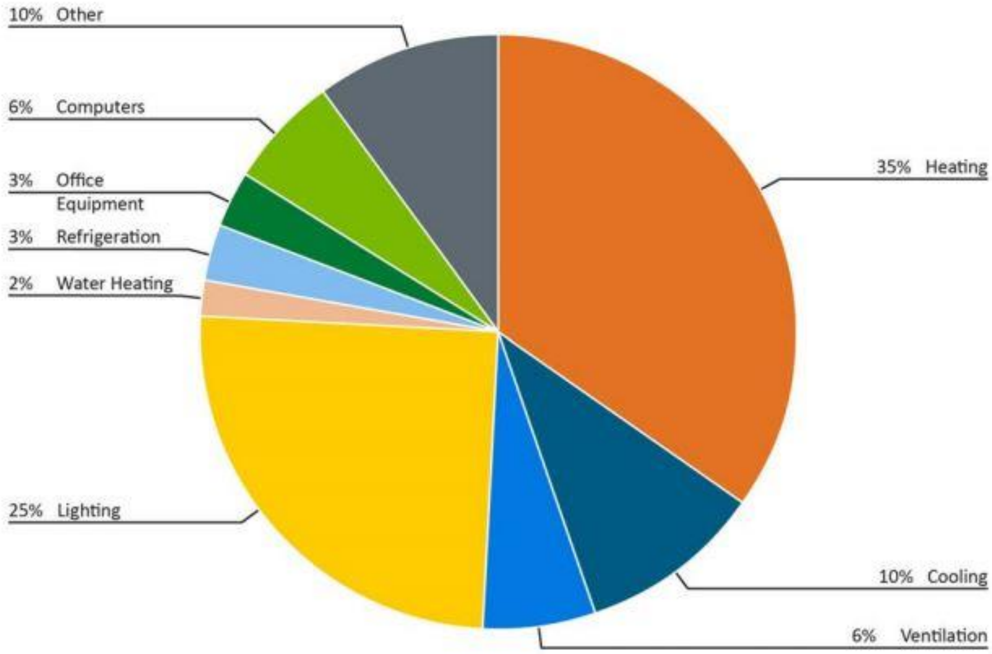

Figure 7: Typical energy usage in an office building (U.S. Department of Energy, 2011)

Through being energy efficient in a building, an organization can improve the operating efficiency and cost to operate they currently face (Building Owners and Managers Association International, 2015). More than 60% of the primary energy mobilized to provide energy services is lost in processing or delivery systems until a building is upgraded to more energy efficient systems (Stuggins, Sharabaroff, & Semikolenova, 2013). This is a staggering number which can be greatly reduced, but not entirely eliminated, through the use of more efficient systems. It is evident that humanity has been unable to perfect a completely efficient system due to human error and the nature of machinery. However, implementing energy efficient technology in a building can greatly reduce this 60% energy loss to something much more manageable and desirable (Stuggins, Sharabaroff, & Semikolenova, 2013).

There is also more to energy efficiency than just helping the environment. Energy efficiency implies that your building is running at its optimal level, which can increase comfort in your building as well as occupant satisfaction (Building Owners and Managers Association International, 2015). Improving energy efficiency can also help a building to reach certain certification levels, such as the LEED certifications (Building Owners and Managers Association International, 2015). From a marketing and recognition standpoint, this can greatly help the image of an organization, institution, or business, and help make them more well-known for efficient sustainability practices.

Being sustainable through energy efficiency is an important aspect to consider when one becomes involved in the retrofitting process.

2.4 Retrofitting Process

Newer buildings are generally outfitted with updated, sustainable technology when they are built. Therefore, retrofitting older buildings with green technology and renewables is the most viable way for a campus or business to reduce their carbon footprint and make themselves more sustainable through renovation rather than new construction. The project work the team undertook heavily involved the retrofitting process, therefore the process and steps involved should be understood deeply.

2.4.1. Retrofitting

As the concern over climate change and switching to cleaner energy sources has gotten more prominent, many older institutions have begun to retrofit their buildings with more energy efficient technologies, as well as energy information systems (EIS) to help monitor their usage levels (Granderson, Piette, & Ghatikar, 2010). The process of retrofitting entails the updating of a building in order to make it more green and sustainable. This often includes updating the heating, ventilation & air-conditioning (HVAC) system, putting in energy efficient technology such as LED light bulbs, and installing water-saving systems.

Many guides have been produced to help not only academic campuses, but also commercial buildings to update their buildings in accordance with green practices. They have been produced by organizations such as the U.S. Department of Energy, the Association for the Advancement of Sustainability in Higher Education (AASHE), and the U.S. Green Building Council. One such guide, the Advanced Energy Retrofit Guide (AERG) distributed by the Dept. of Energy, goes into detail about how to carry out a successful retrofit in an office building, which is similar to what the team has worked on at the IAIA (**Figure 8**).

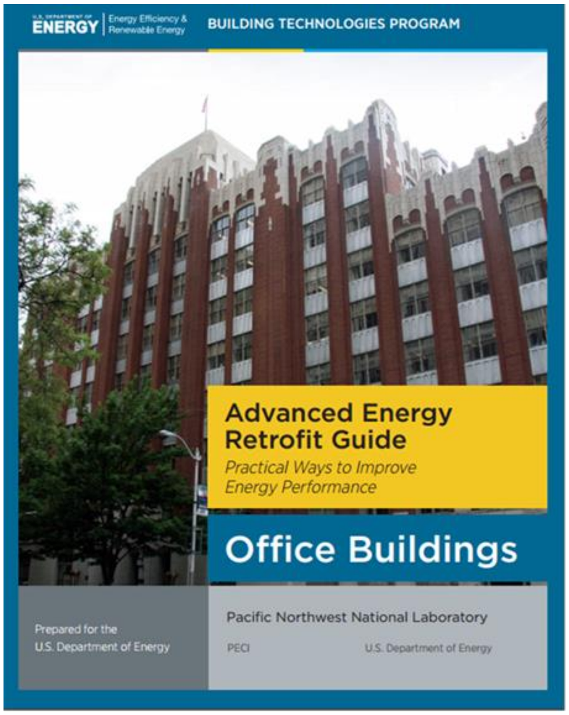

Figure 8: Cover of the Advanced Energy Retrofit Guide (U.S. Department of Energy, 2011)

The AERG was developed in order to improve existing building energy efficiency. It provides the information to help a business or building manager to begin the steps of retrofitting. It also relays the data found from the wide-ranging study done by the Department of Energy that justifies the use of retrofitting as a legitimate tool of achieving carbon neutrality and energy efficiency through data collection and subsequent renovation.

The process of retrofitting has become a routine that can be very easy to follow if it is planned properly. The abundance of guides and resources provided through private organizations, non-profits, and government initiatives are incredibly helpful in developing these kinds of plans. Although each guide differs in how it approaches the steps of a retrofit, the ideology and thought processes behind them stays consistent.

2.4.2. Planning and Implementing a Retrofit

Any errors in recommendation or implementation can be the difference between a more sustainable building and a bill of work that should be redone. Each recommendation should be properly tailored to the particular needs of the building, with respect to both its usage levels and the climate it operates in, which can affect the efficiency of the machines used.

The process that the AERG suggests for creating a retrofit is a 5-step process (**Figure 9**). The IAIA has already begun the process detailed in this guide by making the commitment of signing the ACUPCC and setting the goals they want to reach for energy performance by creating their Climate Action Plan.

Figure 9: Condensed steps to completing a retrofit project (U.S. Department of Energy, 2011)

This is not the only set of steps you can choose to take, however. Another organization, the Building Owners and Managers Association International (BOMA), also provides a set of steps that can be used to retrofit a building to make it more energy efficient. BOMA is more detailed in the sub-steps that an organization can take than the AERG process. In general, the BOMA process is considered easier for the building manager to follow (**Figure 10**).

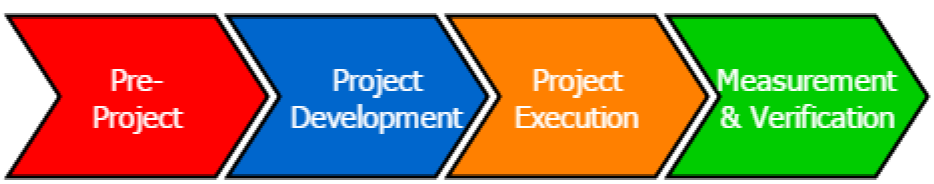

Figure 10: BOMA steps (Building Owners and Managers Association International, 2015)

The process for planning and implementation is highly complex, and takes a significant amount of groundwork and research before taking any action steps. One step that should be considered vital to the planning of a long-term project such as the Climate Action Plan is the possibility of getting an energy audit done. Auditing assists in helping an organization find where they should focus their efforts in a retrofit.

2.4.3. Energy Auditing

The purpose of an energy audit is to develop an accurate breakdown of a building's energy performance and then explore energy saving opportunities through an investigation of the building's current equipment, operations, and energy use patterns. With this information, building operations staff can compare energy saving methods to their potential cost and energy savings. According to the U.S. Department of Energy (2011), there are roughly three steps to an energy audit:

- Pre-site visit analysis
- Site visit data gathering
- Post-site visit analysis and reporting

The pre-site visit analysis is simply a review of any available building information. This can include building plans, construction documents, and any data relating to current energy performance and operations. It is also common for the auditor to contact the building operations staff to learn more about the building's history and day-to-day operations.

The majority of the information collected for an energy audit is obtained during the site visit. In this stage, the auditor conducts a walk-through of the building where they can inspect the utility equipment. The depth of this investigation is determined by the audit type and level (U.S. Department of Energy, 2011).

Once the auditor has collected the necessary information, they can then complete engineering and financial analysis to determine the building's energy efficiency. This report will clarify the building's baseline energy use and describe the potential energy savings from pre-determined building retrofits.

2.4.4. Investment Analysis

The first step in producing funding recommendations is to analyze the investment methods that can be used to measure a project's return on investment. This will help justify the prioritization of the projects as it coordinates between payback periods, energy savings, and potential cash flows. Generally, projects with high return on investment or small payback period are more valuable as the value of the dollar and energy prices will fluctuate over time (Energy Star, 2008). In addition, certain factors must be taken into consideration as the concept of a utility upgrade may eventually pay itself back, but not before requiring additional maintenance costs or the replacement of various components.

Simple Payback Period

The most basic method of measuring a building's financial upgrade investment is defined as the payback period. This is the time, typically measured in years, for the investor's cumulative cash flow to reach zero starting from the time of implementation. **Table 3** demonstrates the expected cash flow from an investment over the span of fifteen years. After an initial investment of $30,000, the institution can expect yearly savings of roughly $3,000. The cumulative cash flow will therefore remain negative until the 10th year where the investor essentially breaks even and any savings from that point on the payback should remain positive. This "simple payback period" method ignores the cost of borrowing money to finance a project.

Year	Initial Investment	Energy savings ($)	Cumulative Cash Flow ($)
0	-30,000	-	-30,000
1	-	3,000	-27,000
2	-	3,000	-24,000
3	-	3,000	-21,000
4	-	3,000	-18,000
5	-	3,000	-15,000
6	-	3,000	-12,000
7	-	3,000	-9,000
8	-	3,000	-6,000
9	-	3,000	-3,000
10	**-**	**3,000**	**0**
11	-	3,000	3,000
12	-	3,000	6,000
13	-	3,000	9,000
14	-	3,000	12,000
15	-	3,000	15,000

Table 3: Theoretical calculation of payback period

The method of thinking involved with this payback period is that the "profit" from the investments could then be applied to other retrofitting projects involved with the IAIA. This cost analysis can be used to create a timeline for the funding of future projects and can be used as a way of measuring the risk involved with a project. There is far less risk associated with a retrofit that has a payback period of one year as opposed to a project that has a projected payback period of twenty years. The shorter the payback, the lower the chances that something will interfere with the productivity of an investment before the initial outlay has been recovered (ENERGY STAR, 2008).

Net Present Value

Net present value (NPV) is similar to the payback period method. However, time is considered as a variable, which has a much larger impact on energy savings. It once again references the concept that the shorter the investment payback period, the "safer" the investment is. The NPV model, however, places more value on near-implementation cash flow, rather than relying on constant cash flows even into the distant future (Energy Star, 2008). Mathematically, this is represented as:

$$\mathbf{PV = CF \times 1(1+r)}$$

Referencing the previous example, r equals the discount rate for the specified period of time that may be expressed as decimal or percentage, e.g. 10% or 0.1, PV represents the present value, and CF is the generated cash flow (Energy Star, 2008):

$$\mathbf{PV = \$3,000 \times 1(1+0.1) = \$2,727}$$

In addition, the investor could take into account the time span in which they wish to analyze their potential payback for an investment. NPV can then be considered as the financial worth of an investment to the organization (Stamats Communications, Inc., 2011). The larger the cumulative NPV, the more valuable the potential investment is and if the total worth were to equal zero, then the organization should consider whether or the not the retrofit is financially worth it at the time. For the IAIA, if there is little to no payback, they may want to consider other investments where the resulting cash flow could be put to into other systems as opposed to simply reducing their carbon footprint. This will all contribute to the institutions long-term goals and the timeline in which they plan to implement various projects (Energy Star, 2008). An example of an NPV calculation can be seen in **Table 4**.

Year	Initial Investment	Energy savings ($)	Present value factor (1/(1+r)^t)	Present value of cash flow ($)
0	-30,000	-	1	-30,000
1	-	3,000	0.909	2,727
2	-	3,000	0.826	2,478
3	-	3,000	0.751	2,253
4	-	3,000	0.683	2,049
5	-	3,000	0.621	1,863
6	-	3,000	0.564	1,692
7	-	3,000	0.513	1,539
8	-	3,000	0.467	1,401
9	-	3,000	0.424	1,272
10	**-**	**3,000**	0.386	1,158
11	-	3,000	0.351	1,053
12	-	3,000	0.319	957
13	-	3,000	0.290	870
14	-	3,000	0.263	789
15	-	3,000	0.239	717
NPV				**-7,182**

Table 4: Theoretical NPV calculation

Internal Rate of Return

The internal rate of return (IRR) is a cash flow analysis tool similar to NPV. It is used in capital budgeting to measure profitability of a specific retrofit (Energy Star, 2008). Essentially, IRR is a discount rate that makes NPV equal zero and operates under the same formula, however NPV is set equal to zero and the equation is used to solve for *r*, or discount rate. Generally, the higher the discount rate or the projects rate of rate, the more desirable the project.

One of the negative aspects of using the IRR as a tool for measurement is that it assumes all cash flows over the life span of the investment can be reinvested at the IRR itself. In addition, the IRR can be a misleading measure if used alone as it does not take into account the initial outlay of the project where the IRR may appear profitable but it may also have a low NPV (Energy Star, 2008). This will result in a slow return on investment.

CHAPTER 3: METHODOLOGY

Mission Statement: The goal of this project was to help the IAIA implement its 2050 Climate Action Plan and thereby further reduce the carbon footprint of the institution. The team identified solutions to help reduce the usage of electrical utilities while also preparing recommendations for future projects.

Objectives

1. Identify and implement an affordable electrical metering system to assist the IAIA in beginning the measurement & verification process at their campus.
2. Research and recommend low-risk, cost-effective electrical retrofits, such as LED replacement bulbs, that the IAIA can implement to reduce electrical costs and greenhouse gas emissions.
3. Provide recommendations for the IAIA to continue project work that advances their Climate Action Plan.

3.1 Identify and implement an affordable electrical metering system to assist the IAIA in beginning the measurement & verification process at their campus.

One objective that emerged at the beginning of our project work was the need for individual building-level measurement of electrical usage. When the team spoke to Mr. Mason about his goals for the project, he stressed that he was unable monitor the individual campus buildings' electrical usage and was unable to see where money could be saved through retrofits because he only had a meter at the street, which gave the entire campus's electrical usage (Mason, 2016).

Therefore, the objective of providing our sponsor with affordable and functional electrical metering became a priority.

3.1.1. Measurement and Verification

The monitoring of gas and electric use should be observed carefully to ensure energy is not being wasted, as well as to track energy distribution between utilities (U.S. Department of Energy, 2011). An energy metering and monitoring system can collect such data and track usage over time. Understanding what the building currently requires to operate can also help illustrate the benefits of new energy saving technologies.

The Advanced Energy Retrofit Guide (AERG) provided by the U.S. Department of Energy (2011) describes meters and their accompanying software as tools for Measurement and Verification. Measurement and Verification (M&V) is a necessary practice for determining the actual savings from an energy-efficiency retrofit project, but it is much more than simply comparing energy use before and after a retrofit. For example, the IAIA may find that their cost savings can fluctuate depending on the time of year and how busy their campus is.

Energy bills can also fluctuate based on a number of factors such as weather, student population, and activities or events which correspond to that building, so monitoring individual locations will highlight any potential savings when compared to the data collected from previous months. The AERG outlines proven M&V strategies that account for these fluctuations. This information can then be shared with stakeholders to potentially celebrate success and encourage future renovations.

3.1.2. Electric Metering at the IAIA

Prior to our team's arrival, the IAIA received a single gas and electric bill for the entire campus, which encompasses eleven buildings. This makes determining the effects of energy retrofits on specific buildings challenging.

Our team arranged the installation of metering devices on two campus buildings. Implementing meters on two buildings initially also allows the IAIA to test out the associated software to ensure that it is usable for their needs. The buildings we chose to monitor are the largest facilities on campus and those projected to consume most energy (building numbers 3 and 10, **Figure 11**).

Figure 11: IAIA campus map (Institute of American Indian Arts, 2016)

The Academic Building (AB) is roughly 30,000 sq. ft. and encompasses rooms for administration, offices, art studios, and art galleries. These rooms operate all hours of the business day, and some rooms also operate after hours. Based on the size of the building and its usage level, it was the primary candidate for energy metering. There are numerous retrofits which can be done to this building, but prior to the implementation of these projects it is crucial to have a baseline for energy use and a history of information which can be provided to auditing companies. These companies can use the information specific to the building to provide a more accurate energy model as well as stronger recommendations tailored to the unique characteristics of the building.

Figure 12: Transformers in the AB

The AB's electrical system is comprised of two identical V-Class transformers (**Figure 12**). The electrical size of the transformer load is 150.0 kVA. This rating coincides with the power output delivered for a specific period by the loads connected to the transformer on the secondary side of the equipment. The wiring configurations and amperage are determined by the type and load size of the transformer (**Figure 13**).

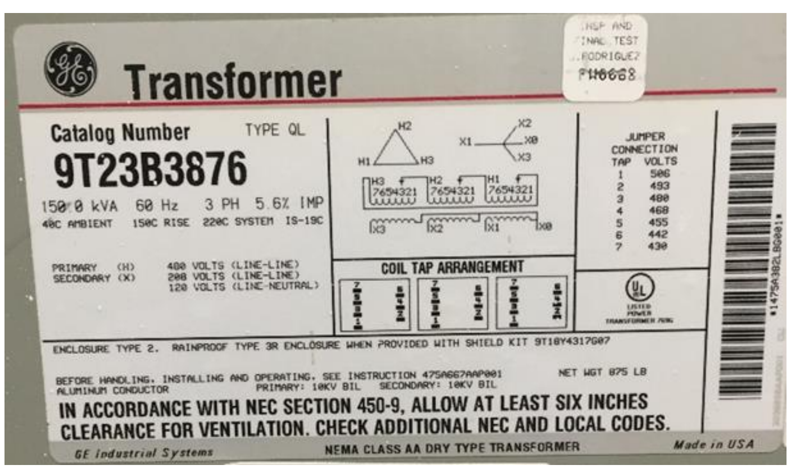

Figure 13: Wiring and amperage schematic for AB transformers

The Sculpture and Foundry ("Foundry") building was the second priority due to the sheer amount of energy usage it sees in a typical day. This building contains the equipment and resources for students to use in their woodworking, welding, forging, casting, ceramic, stone, and glass sculptures. These machines consume large amounts of power and are generally inefficient. The information provided from metering equipment can help the IAIA coordinate class times in relation to the time of day so that HVAC and lighting systems are not overused. This will reduce peak loads, thereby increasing cost savings from electricity and natural gas bills.

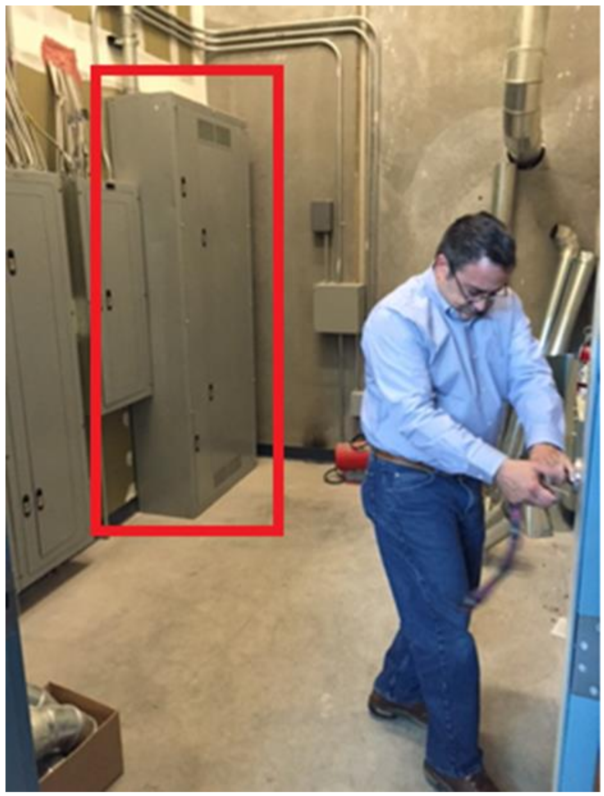

Figure 14: Main electrical panel in the Foundry

The Foundry contains one main panel that feeds into the transformer through the ground (**Figure 14**). When our team examined the electrical room in the Foundry, we found a monitoring system installed that was nonfunctional. This meter was replaced with the system we decided to implement, as it was not compatible due to it being of a different make than the system we selected. The Foundry's transformer, unlike the AB's, is located outside (**Figure 15**).

Figure 15: The Foundry's transformer

To procure metering for the IAIA, the team looked at several companies who provided the services our sponsor had asked for. One feature that needed to be included was data collection software that would gather the data the meters output and put it into a repository that the IAIA could access. The software and its usability were a priority for our sponsor because the IAIA intends to use the data collected to plan future projects that will reduce electrical usage.

Figure 16: Collecting information on the electrical panels in the AB

After identifying possible metering brands, the team then contacted distributors in the area that could provide a quote for one building, the AB. The distributors asked for specifics on the types of transformers and the number of panels employed in the AB, which the team collected (**Figure 16**). The distributors provided the team with a bill of materials, which became a quote for cost of materials after the team decided on a system to implement.

3.2 Research and recommend low-risk, cost-effective electrical retrofits, such as LED replacement bulbs, that the IAIA can implement to further reduce electrical costs.

When it came to project work, the aspect of artificial lighting usage reduction that the team focused on was the replacement of inefficient lights with LEDs. At the start of the project, the IAIA mainly relied on fluorescent and other inefficient lighting sources Through research and work, the team sought to find the correct type of LED bulbs to recommend to the IAIA, and then find distributors for the bulbs the team found best. An important consideration taken into account was the impact that lighting has on student life at the IAIA. Maintaining the best lighting levels possible for the artistic nature of the work students do influenced this process.

Another important point that needed to be taken into consideration was the type of lighting replacement the team recommended. The IAIA experimented with replacing their current fixtures entirely with LED-specific fixtures (Mason, 2016). This prior project was more expensive than was feasible for a large-scale replacement project, so the team resolved to find a less expensive way to get similar results.

3.2.1. LED Lighting

In advancing the lighting aspect of this project, the team created a tool for inventory and analysis of the current lighting on the IAIA's campus. This spreadsheet was intended to assist in calculating cost savings as well as documenting changes in lighting as the IAIA takes steps towards more efficient lighting solutions. To properly populate this spreadsheet, the team surveyed each of the buildings we focused on and totaled the number of lights present in each room. This spreadsheet further categorized the lights by which type of light they were, such as fluorescent, CFL, or incandescent bulbs. Using the lighting information collected, along with the industry standard estimated cost of running these types of bulbs, the team was able to calculate the cost of each room based on its total lighting usage.

To properly provide LED recommendations, the team researched different types of replacement bulbs online. After finding a suitable type, the team contacted local distributors to find a quote for the IAIA to purchase 25-100 bulbs for the IAIA to test out.

3.2.2. Measuring Illuminance Levels

As the IAIA looks to replace their current lighting with LEDs, the concept of illuminance should be understood and considered. Illuminance is the intensity of an object that is illuminated by a light source. The need to measure illuminance exists because, unlike fluorescent or incandescent lighting, wattage cannot be used as a reference point for the output of the light when utilizing LEDs. This change in measurement is due the fact that LEDs produce a comparable light output with lower wattage (The LED Light Inc., 2016).

There are two units of measurements for illuminance, foot-candles and LUX. Foot-candles is the American unit of measurement and is the amount of light a candle produces one foot away (The LED Light Inc., 2016). LUX is "lumens per square meter" and is the SI unit of measurement (The LED Light Inc., 2016).

To take measurements around the IAIA's rooms, an Extech Instruments Light Meter LT300 was used and set to read illuminance in LUX. The following process was used to assure illuminance measurements were accurate and consistent from room to room. This process was also created with the intention that they would be able to be repeated when replacement bulbs are introduced. The process varied slightly depending on the amount of natural light that a room received.

Figure 17: Measuring illuminance levels in the AB

The number of times that measurements were taken depended on the presence of natural light in a particular room (**Figure 17**).

Two processes were created for two specific classrooms situations. The situations differed based on the presence of natural lighting in the classroom.

For a classroom with natural light, the following measurement procedure was developed to accommodate varying sunlight levels (Autodesk Inc., 2016).

1. One measurement was taken at the beginning of the school day, at approximately 9:00 AM.
2. A measurement was taken midday, at approximately 12:00 PM.
3. A final measurement was taken towards the end of the business day, at approximately 3:00 PM.

A special case was developed for the studio classrooms. These classrooms do not close at the end of the business day, unlike most other classrooms at the IAIA. Due to these extended hours, a fourth measurement was required.

4. A measurement was taken at night, to reflect the absence of natural light.

For a classroom without natural light, the following shorter procedure was developed due to lack of variation in light levels.

1. A measurement was taken at any time of the day.

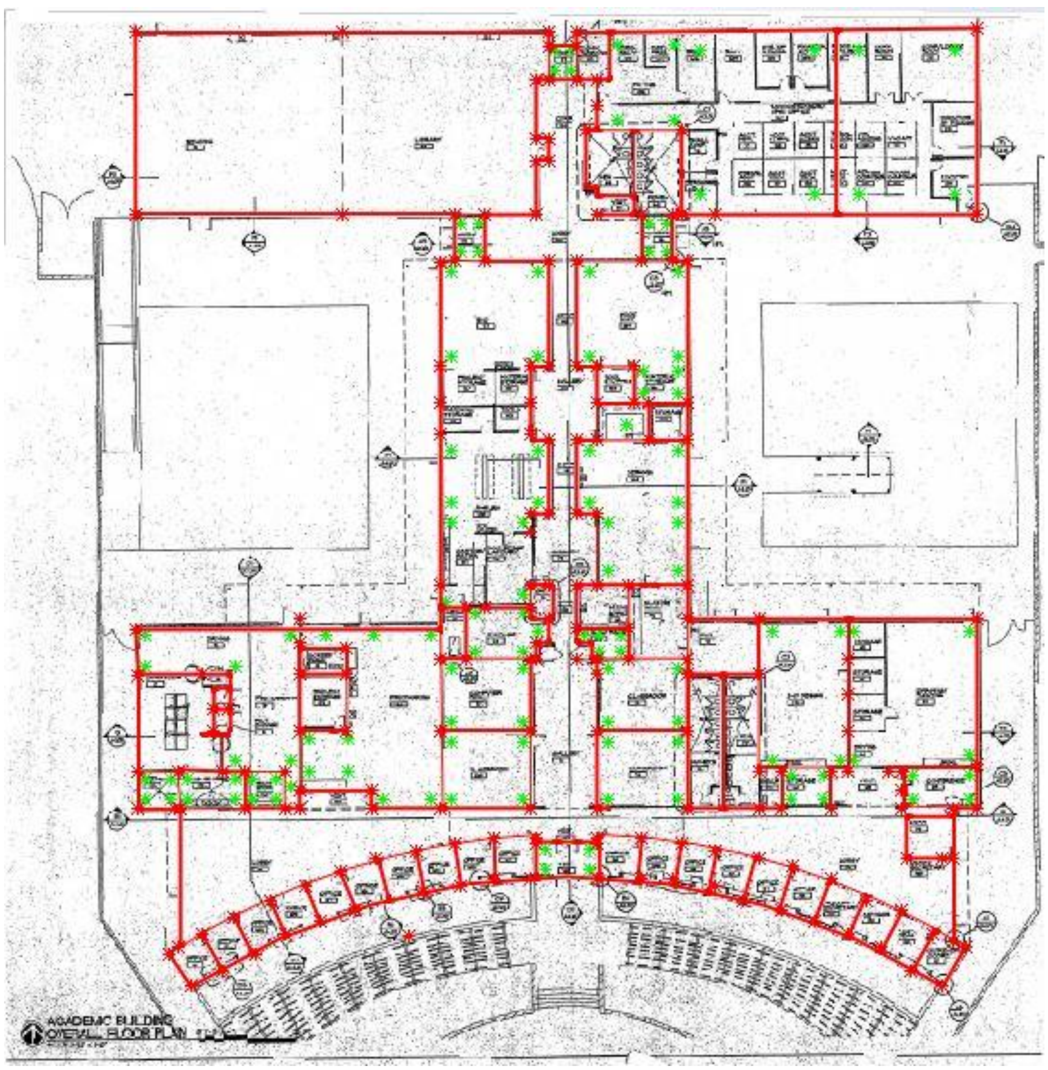

Figure 18: Illuminance measurement locations in AB

In addition to the number of measurements taken in a particular room, the positioning of the measurements was also considered in this process. The Light Meter LT300 was set to the MAX MIN mode and the person taking measurements walked around the room to find the maximum and minimum lighting levels. As the sensor was held, the person taking measurements was careful to avoid shadows cast by objects around the room such as, tables and computers, but also shadows cast by the user. As well as the maximum and minimum measurements, additional measurements were taken at approximate locations within the rooms to provide a range (**Figure 18**).

3.3 Provide recommendations for the IAIA to continue project work that advances their Climate Action Plan.

The project work undertaken revealed much about the way a retrofit generally occurs at the IAIA. Even with this experience, the team still did not consider ourselves to have enough expertise or time to fully flesh out a deeper retrofit project, such as a project to pursue solar electricity. Therefore, the team resolved to provide recommendations for future work at the IAIA.

To do this, the team reflected on the work accomplished during our time at the IAIA, and took into account the circumstances and needs Mr. Mason had expressed for the future (Mason, 2016). The team also considered the industry expertise provided in guides and handbooks on retrofitting. With these two sources of knowledge, the team developed a set of recommendations for the IAIA's future project work.

CHAPTER 4: RESULTS AND ANALYSIS

This chapter addresses the project's core objectives and presents the pertinent results. These objectives were agreed upon between Mr. Mason and the team, and encompassed much of the team's project work.

The team's two deliverable objectives comprised of beginning the measurement & verification (M&V) process and providing shallow retrofit solutions (**Figure 19**). The M&V phase was completed through the team arranging electrical metering for the IAIA's campus. This arrangement allowed for proper data collection.

The objective of providing shallow retrofits was accomplished through the creation of the Lighting Inventory & Analysis Spreadsheet (LIS), an analytical tool the team created to help calculate cost savings through the replacement of inefficient lighting with LEDs. The team recommended the correct type of LEDs for the IAIA to utilize in upgrades as well as ensuring that the lighting levels in buildings would be satisfactory. The team also explored other electricity-saving technologies.

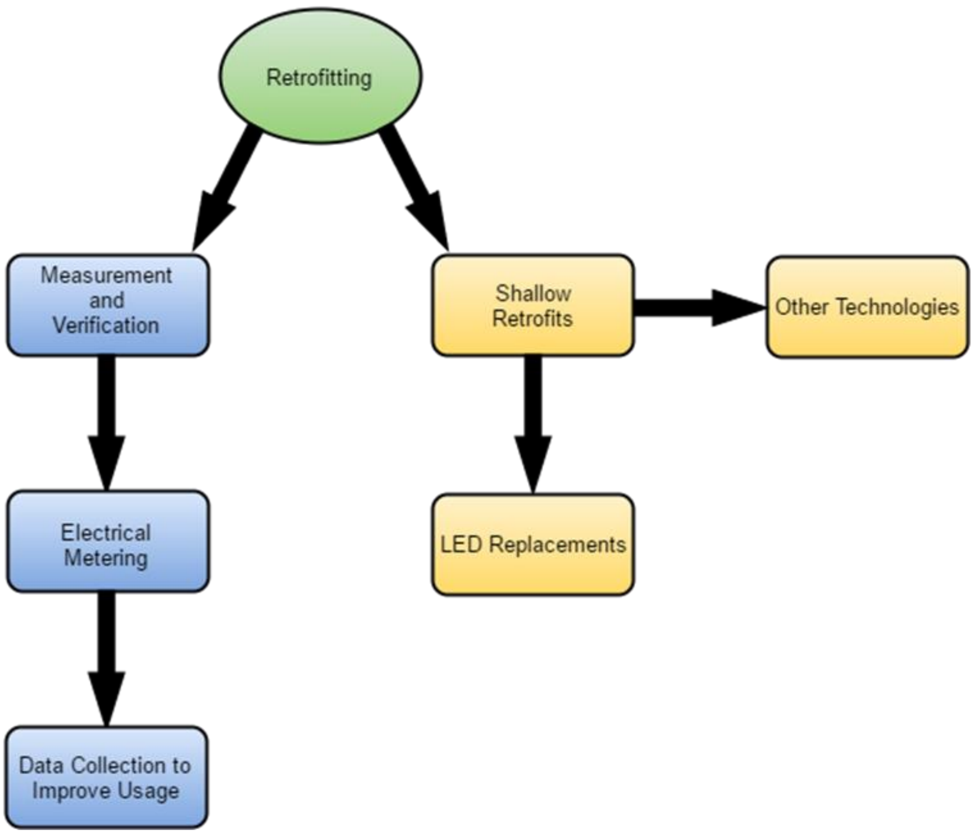

Figure 19: The retrofitting scope of the project

4.1 Measurement and Verification

Measurement & Verification (M&V) is the practice of measuring, computing and reporting the results of energy saving projects (U.S. Department of Energy, 2011). M&V can be accomplished by conducting site surveys, metering energy use, monitoring independent variables such as outside temperatures, executing engineering calculations, and reporting. The team secured electrical metering for the Academic Building (AB) and the Allan Houser Haozous Sculpture & Foundry Building (Foundry) that will allow Mr. Mason and his staff to readily access hourly data on the energy usage of these two buildings.

Providing the IAIA with this data will not only allow the data to be seen; this data will influence how the IAIA decides to schedule classes and seminars, as well as the types of retrofits they choose to pursue in these buildings. The effectiveness and cost efficiency of this system will also determine whether it will be installed in the IAIA's remaining unmetered buildings.

4.1.1 Finding: Leviton Metering System is the Best Option for the IAIA

		Honeywell	Leviton
Display	kWh	●	●
	kW Demand (Peak)	●	●
	Energy Distribution	●	●
	Amps per Phase	●	
	Volts per Phase	●	
	LCD Display	●	●
		Honeywell	Leviton
Cost	Complexity of System	2 Meters & 1 Hub	2 Meters & 1 Hub
	Cost Per Meter	$1000-$1400	$700.00
	Cost Per Hub	$2,800	$1,475.00
	Software	$2,000	Free
	Additional Costs	N/A	$1,000
	Labor	$500-$1500	$500-$1500
	Estimated Total per Building	$7300 - $9100	$4,375 - $5,375

Table 5: Comparison of Honeywell and Leviton metering systems for the IAIA

Our team researched two different metering systems. The first system, which was our initial pick for the IAIA, was made by the company Honeywell. The second system researched was created by Leviton. Based on specs alone, the Honeywell system initially seemed like a better choice for the IAIA. The Leviton system, which has the same functionality, was ultimately more affordable despite its shortcomings (**Table 5**).

Figure 20: Leviton metering process (Leviton Manufacturing Co., Inc., 2016)

In the Leviton system, meters are connected downstream of the transformer in each electrical room, which will collect electrical output from the transformer and accurately measure how much electricity is being used in a particular building. These meters are connected to a central hub that is wired into the building's Ethernet connection and they upload the collected data to the repository on the E-Mon software, where a user can access it (**Figure 20**). The Leviton meters utilizes the E-Mon software as its main data collecting service (**Figure 21**).

Figure 21: Example of Leviton data collection software (Leviton Manufacturing Co., Inc., 2016)

The team recommended that the IAIA test these meters on the AB and Foundry. During the project work, our team had the opportunity to sit down with the President of the IAIA, Dr. Robert Martin, and during this meeting, he expressed interest in metering the whole campus in a similar fashion (Martin, 2016).

Figure 22: IAIA campus with metering status (Institute of American Indian Arts, 2016)

With this in mind, the team contacted the distributor, and then began the quote process for the 6 buildings with priority on the IAIA's campus. **Figure 22** displays the IAIA's campus with the metering status of each building displayed. The buildings circled in green are the buildings that have already had their meters ordered, the buildings in blue are the buildings the team has received a quote for, and the buildings in red are the buildings for which the team has received a bill of materials. Information on the metering orders can be seen in **Appendix A**.

Although the team received positive feedback on the metering system, the team has advised that the IAIA only meter the AB and the Foundry for an initial trial period. This is to ensure that the meters and their accompanying software are easy for the IAIA to use.

4.2 Low-Risk, Cost-Effective Electrical Retrofits

Types of Lights Used in the AB
• **Fluorescents** • **Halogens** • **CFLs** • **LED fixtures**

Table 6: Types of lights used in the AB

To help make energy efficient upgrade recommendations for the IAIA's campus, the team investigated the possibility of retrofitting some classrooms and parts of their buildings with drop-in replacement LED or CFL tubes. Currently, the AB uses a mixture of bulbs to provide adequate lighting (**Table 6**).

Prior to our project, Mr. Mason had already attempted to approach this issue by having the fluorescent fixtures in the Northwest Classroom in the AB upgrade to LED-specific fixtures (**Figure 23**). This was a step in the correct direction; however, the fixture replacements cost well over $1000, and the lights are still not ideal for what the IAIA would like in terms of brightness. The IAIA decided to try avoiding the replacement of fixtures and instead look for drop-in replacement bulbs. To avoid replacing fixtures, there are two types of LED retrofit lighting that can be installed.

Figure 23: LED fixture replacement

The team explored the possibility of recommending that Mr. Mason purchase 1000 bulbs to help update an entire building. However, this was decided against in favor of recommending that a small amount of bulbs be bought. Buying a smaller quantity of bulbs will allow for the IAIA to experiment with lighting brightness and tone.

This experimentation will also allow for student and faculty input which, considering the artistic nature of the work done at the IAIA, is important if the IAIA plans to pursue a full building replacement project. There are many factors that should to be considered in any retrofit. For this particular project, what should be considered is the type of replacement bulb used as well as the layout of the fixtures in each room.

4.2.1. Finding: Lighting Inventory & Analysis Spreadsheet Can Be Used to Calculate Energy Savings

Current Annual kWh Usage:	74538
Current Approximate Annual Carbon Emission(lbs):	125424
Projected Annual kWh Savings:	34849
Projected Reduction in Annual Carbon Emissions (lbs):	58651

Figure 24: AB Bottom line data from Lighting Inventory Spreadsheet

One solution to the issue of installing more efficient lighting that we were able to provide was the creation of a lighting inventory & analysis spreadsheet (**Figure 24**). This lighting inventory document was a way for the team to roughly estimate the amount of money each individual room in a building cost due to the usage of light, and the spreadsheet is available **here**.

The current estimates given in Figure 24 were calculated using the following data:

- Type and number of lights installed
- Number of hours each light is on
- The cost to operate per bulb

The projected estimate given in Figure 24 was calculated using the following:

- Assuming that the IAIA switched all lights in the AB to LEDs
- The cost to operate each LED bulb

To further aid the IAIA's Climate Action Plan, the team also estimated carbon emissions due to lighting (**Figure 24**). This was based on an 1.683 lbs./kWh standard for New Mexico (U.S. Department of Energy, 2016).

In the AB alone, the IAIA's lighting usage is over 6.8 times that of the total electrical usage of the average American household (**Figure 25**), which is approximately 11,000 kWh (U.S. Department of Energy, 2015).

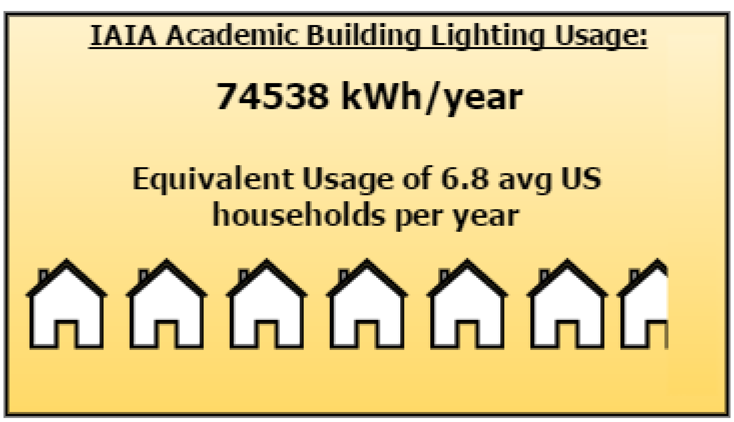

Figure 25: Equivalent usage of lighting in AB (U.S. Department of Energy, 2015)

The team endeavored to make this spreadsheet easy to read, categorize, and use. The clarity and ease of use of the spreadsheet were important criteria for this deliverable because the team intends to leave this spreadsheet for the IAIA to use in future retrofits.

4.2.2. Finding: Direct Replacement Bulbs Are More Cost-Efficient and Safer than Fixture Replacement

There are two types of replacement bulbs that the IAIA can consider in this situation. The first type is a direct replacement LED tube that can be dropped into the existing fixture and is compatible with the ballast located in the fixture. The second type is a ballast-bypass which requires that the ballast be removed and that voltage be wired directly to the fixture sockets.

Advantages of direct replacement LED tubes compared to ballast-bypass (Regency Lighting, 2016)**:**

- **Installation time is reduced** because the tube is placed into the fixture just as if a new fluorescent tube was being installed, saving labor costs.
- **Safety is improved** because installer time on ladder is reduced and the risk of being shocked when installing the lights is also reduced, which is a possibility with ballast-bypass because the socket is carrying line voltage.

Disadvantages of direct replacement LED tubes compared to ballast-bypass (The LED Light Inc., 2016):

- **Cost is increased** because direct replacement LEDs are more expensive to develop and manufacture.
- **Compatibility is not guaranteed** because not all direct replacement LEDs are compatible with different types of ballasts.
- **Ballast maintenance is not removed** as a result of direct replacement LED implementation, as there is still some stress on the ballast with this bulb.

Advantages of ballast-bypass LEDs compared to direct replacement LED tubes (Regency Lighting, 2016):

- **Ballast maintenance is no longer a factor** because ballast-bypass LEDs require removing the ballast from a fixture altogether.
- **Wattage of the LED is not reduced** because the removal of the ballast prevents the loss of wattage when the LED is on.

Disadvantages of ballast-bypass LEDs compared to direct replacement LED tubes (Regency Lighting, 2016):

- **Labor is more complicated** because ballast-bypass requires an entire rewiring of the fixture, and there is no industry standard for fixture wiring.
- **Danger to staff is increased** because ballast-bypass is not compatible with fluorescents, and mistakenly installing a fluorescent into the updated fixture can be a safety risk.

After considering all the advantages and disadvantages, the team recommends that the IAIA pursue the use of direct replacement LEDs on their campus. A concern arose about ballast compatibility, but the local distributors the team contacted already had an established relationship with the IAIA and this issue was circumvented. Ultimately, the reduced cost and increased safety of the direct replacement LEDs outweighed the benefits of the ballast-bypass system.

4.2.3. Finding: Illuminance Levels Can Be Maintained Despite Differing Light Sources

When recommending lighting purchases, the team identified the need to maintain and improve overall lighting levels at the IAIA. Due to the highly artistic nature of the IAIA, the lighting levels are vital in ensuring that individuals' artistic processes are not disturbed. To aid in this, it was determined that the beam angle would be an important factor to maintaining the lighting level.

Measurements were taken to insure that lighting levels will be at the minimum maintained when LEDs replace the current 4 ft. fluorescents. Measurements taken in the AB ranged from 57 to 3641 lumens. The measurements taken were entered into the spreadsheet to be documented (**Table 7**).

Room	Natural Light	Maximum (10 a.m.)	Minimum (10 a.m.)	Maximum (Noon)	Minimum (Noon)	Maximum (3 p.m.)	Minimum (3 p.m.)
Jewelry Studio	West	1127	300	1221	264	1450	211
Ceramic Studio	East	1189	251	1017	323	1067	214
Advanced Painting Studio	North and South	1288	696	1831	768	1538	750

Table 7: Illuminance levels measured in the AB

Two rooms that required special attention were the Northwest AB and Southwest AB classrooms. These rooms are identical with the exception of their lighting fixtures. The Northwest AB classroom is the classroom that has already been upgraded with LED fixtures (**Figure 18**). The Northwest AB classroom had a higher maximum and lower minimum reading compared to the Southwest AB classroom, which can be read as a direct result of the LED replacement. The team considered this when researching LEDs to ensure that all prior lighting levels could be maintained.

With the documentation of illuminance levels in buildings across the IAIA's campus, the team determined that the replacement LEDs will be able to match the initial readings we gathered. This finding also allows for rooms with sub-par lighting to be improved.

4.2.4. Finding: Line Loss Pro System Would Not Benefit the IAIA

During this project, a technology was brought to the attention of Mr. Mason. This technology was an electrical efficiency device provided by Line Loss Pro, Inc. The Line Loss Pro (LLPro) system endeavors to reduce commercial energy usage through the use of passive electromagnetic harmonics to reduce noise in electrical current (Line Loss Pro Inc., 2016). The process is supposed to help prevent energy loss, and thereby make it more energy efficient. The technology operates by being plugged into the neutral bus of every electrical panel in the building. Since it is a passive device, there is not any setup, operation, or maintenance required while running the LLPro; it is just supposed to work once installed.

We explored this option as one we could potentially install in either the AB or the Foundry, but several disadvantages came to light:

- The uncertainty of whether this product would benefit the IAIA
- The IAIA experiences abnormalities in how their power operates ("dirty" power)
- The LLPro only offers a leasing option for their technology

The team did speak to the company rep who initially contacted Mr. Mason, but ultimately the team did not think we had the expertise to fully understand the nature of the LLPro. Therefore, the team decided to consult with a professor of electrical engineering at WPI, Professor John Orr, for his expert opinion on the technology.

Professor Orr was very helpful, sharing his impressions that based on our descriptions and the information from the LLPro website, that the technology's validity was not high. His professional opinion was that the technology would not deliver the results the LLPro promised, and while the science behind the technology was correct, there would be no actual benefit to installing the technology since the possibility of the LLPro increasing cost savings was slim (Orr, 2016). Ultimately, we wanted to provide the IAIA with proven technology that would help them move towards optimal energy efficiency. In our considered opinion, the Line Loss Pro would not meet these criteria.

CHAPTER 5: RECOMMENDATIONS

Based on the project work, the team has provided six recommendations in regards to future project work. The work the team completed has provided the IAIA with the means to continue with retrofit projects and further their Climate Action Plan efforts.

These recommendations were developed with the knowledge that a further WPI IQP group is arriving to continue working with the IAIA in the fall of 2016. This quick turnaround time between projects required that the team be thorough in what we recommended and provide feasible next step recommendations. This chapter outlines all of the recommendations the team created. The recommendations are:

1. The IAIA should have an energy audit done on the buildings they intend to retrofit further.
2. The IAIA should utilize data from the metering system in planning event and academic scheduling.
3. The IAIA should develop a systematic approach to future retrofitting projects that aligns with the goals they wish to achieve through their Climate Action Plan.
4. The IAIA should consider other devices that reduce gas and water usage.
5. The IAIA should establish a revolving fund and explore other options to finance retrofit projects.
6. Students enrolled in the sustainability class at the IAIA should aid in data collection.

5.1 The IAIA should have an energy audit done on the buildings they intend to retrofit further.

The team is strongly recommending that the IAIA have an energy audit performed on the buildings they wish to retrofit further, such as the Academic Building (AB) and the Sculpture & Foundry Building. An energy audit provides an accurate read of the energy performance and explores energy saving opportunities, creating an energy baseline.

An ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Level II audit (U.S. Department of Energy, 2011) should be performed for either of these buildings due to their size and usage levels. An energy audit of this level will illuminate potential savings in regards to artificial lighting, HVAC, plug-in loads, and plumbing (**Figure 26**). As a part of the audit, the IAIA should request an energy model that will provide the school with information regarding the initial project cost, return on investment, and overall savings.

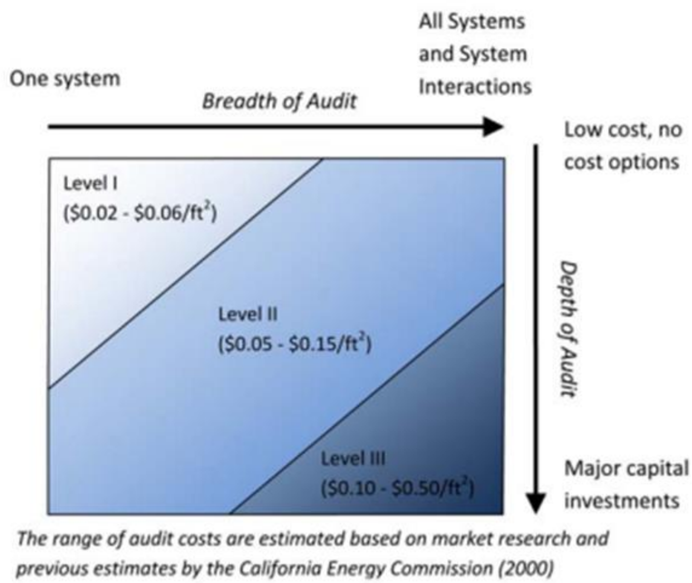

Figure 26: ASHRAE audit breakdown levels (U.S. Department of Energy, 2011)

The cost and depth of the audit correlate directly, and the Level II audit provides a good combination of breadth and depth at a reasonable cost (**Figure 26**).

5.1.1. An energy audit will provide solid, expert evidence for grant support

A primary benefit of an energy audit is that the report will provide reputable analysis that the IAIA's grant writers can use to support their case when requesting funding for energy retrofits. The proposal portion of the grant application often requires the following:

- The application form as a cover sheet
- A clear statement of the need(s) or problem(s) to be addressed
- Strategy
- Timeline
- Results you expect from your project
- Project budget – including a brief explanation of the budget, a list of other sources of actual and potential funding for the project, and a description of plans to secure additional funding
- How you will determine whether your project is successful
- History of organization, including mission and goals

The energy model portion of the audit provides grant information such as initial costs, payback periods, and overall savings. Essentially, the energy model portion of the audit will theoretically implement an energy retrofit, and project the savings. With the correct verbiage, the IAIA can ensure the success of a project while highlighting the primary obstacle, funding.

One particular grant foundation, the Energy Foundation, requires several documents for their application, one of which is a recent energy audit report (Energy Foundation, 2016). Since it is a required document for this and other grants, the IAIA should perform energy audits on buildings that require additional funding for deep retrofits.

5.1.2. Timeline: Audit reports can be used to catalog the retrofits in a profitable sequence

The energy model portion of the audit report can be used by the IAIA to organize the projects in a profitable sequence. For example, projects with a relatively fast payback period such as replacing fluorescent bulbs with LEDs can be tackled first because after roughly two years the IAIA will have recovered its costs and begin profiting financially from the upgrade. These profits can then be set aside to fund an additional retrofit such as occupancy sensors. This process can continue and energy upgrades can be organized in a sequence to optimize the retrofitting process.

5.1.3. Companies Recommended for Audits in the Local Area

The team compiled a list of auditing companies within the Santa Fe and Albuquerque region (**Table 8**) and received quotes for the IAIA's AB building from Vibrantcy and Energy Control Inc. Both companies are capable of performing an ASHRAE level II audit for $5,500 and $6,000 respectively. These quotes include an energy model for projects regarding lighting, plug-in loads, plumbing, and HVAC.

	Audit Companies:	Green: Residential and Commercial Company Red: Residential Company		
Company:	Website:	Type of Communication:	Received Quote (Y or N)	Quote/Rate:
DA Solar Energy	http://www.dasolar.com/	Online Request Form	N	n/a
Consumer Protection, Inc.	http://www.cpinm.com/	Left Voicemail	N	n/a
Green Insight	http://www.thegreeninsight.com/	Online Request Form	N	n/a
Holistic Energy Rating Specialists	http://www.holisticrating.com/	Online Request Form	N	n/a
Vibrantcy	http://www.vibrantcy.org/Home_Page.php	Phone Call w/ Matthew Higgins	Y	$5,500
B & D Industries, Inc.	http://banddindustries.com/contact-us/	Online Request Form	N	$81.00 per/hr
Bridgers & Paxton	http://www.bpce.com/contact	Left Voicemail	N	n/a
Energy Control Inc. (ECI)	http://www.energyctrl.com/	Phone Call Ww/ John McAllister	Y	$6,000
Noresco	http://www.noresco.com/	Left Voicemail	N	n/a
WH Pacific	http://whpacific.com/contact/	Online Request Form	N	n/a

Table 8: Auditing companies in the Albuquerque-Santa Fe area

5.2 The IAIA should utilize data from the metering system in planning event and academic scheduling.

One aspect of the project that has excellent potential to have lasting impact on the IAIA's campus is the newly recommended metering system. Although the team will not be able to see any of the long-term data that will be collected through Leviton's system and the accompanying E-Mon software, this data will assist in decision making about event planning and academic scheduling.

By analyzing the data collected from the meters and analyzing trends in electrical usage, the IAIA can determine:

- Where the peak usage occurs in each building
- What usage triggers their peak rate from Power New Mexico (PNM)
- Solutions to increase energy and financial savings (i.e.: changing a class time to increase energy savings during peak usage)

5.3 The IAIA should develop a systematic approach to future retrofitting projects that aligns with the goals they wish to achieve through their Climate Action Plan.

Large-scale retrofits are difficult to accomplish without detailed plans. Therefore, the team recommends that the IAIA utilize industry-level expert guides and resources to plan their deeper retrofits. The process detailed in this recommendation is lengthy and includes steps and recommendations derived largely from three key resources that we also recommend to the IAIA**:**

- Advanced Energy Retrofit Guide (AERG) for Office Buildings (U.S. Department of Energy, 2011)
- BOMA Energy Performance Contracting Model (BEPC) (Building Owners and Managers Association International, 2015)
- ENERGY STAR: Guidelines for Energy Management (Energy Star, 2013)

The 5-step process described below is as follows:

1. Make the commitment.
2. Set goals for performance.
   a. Data collection and management process.
   b. Baselining and benchmarking practices.
   c. Analyzation and evaluation process.
3. Create an action plan for the retrofit.
4. Implement the project.
5. Evaluate the project and recognize goals that were achieved.

Step 1: Make the commitment to a retrofit project.

The IAIA made a commitment to become a carbon neutral campus in its CAP and by signing the ACUPCC. Members of the committee are to propose annual sustainability projects (Institute of American Indian Arts, 2013). The team recommends that a fundamental approach to implementing the CAP exist at the IAIA. This approach can be accomplished through individual as well as group efforts.

Step 2: Set goals for building performance.

After making the commitment, goals need to be set for the energy and emissions performance of the campus, both as a whole and on an individual building scale. The implementation of a standard energy policy can contribute greatly to the effort to move ahead in sustainability. The energy policy would state an objective, establish accountability, looking for continued improvement, and promote goals. The goal should be something that is achievable, but before that is set there is a need to understand the amount of energy currently being used (U.S. Department of Energy, 2011). The audit is a first step (Recommendation 1).

If an energy audit is not feasible for the IAIA, building performance should still be assessed in a different process. Energy Star breaks this down into three key aspects: Data Collection and Management, Baselining and Benchmarking, and Analysis and Evaluation (Energy Star, 2013).

1. **Data Collection and Management Process**: The process of retrofitting starts with collecting complete and accurate data for analysis and goal setting. The Facilities' department at the IAIA should:

a. Determine the thoroughness of data collection (i.e.: how long data collection will be, etc.)
b. Determine which energy sources will be monitored, and inventory all the energy in physical units and cost by assembling bills and getting meter readings (Energy Star, 2013).
c. Carefully monitor gas and electric use to ensure energy is not being wasted and to track energy distribution between utilities (U.S. Department of Energy, 2011).

2. **Baselining and Benchmarking Practices** The IAIA has made steps to establish a campus-wide baseline for their energy usage and carbon emissions, which can be applied to individual buildings. To create a project baseline, the IAIA should (U.S. Department of Energy, 2011):
    a. Create energy usage and carbon emission baselines for individual buildings.
    b. Publish the results of the baseline and make them available to stakeholders.

After taking these steps, the IAIA can start benchmarking the performance of the building. The most common benchmarking comparisons and their descriptions can be found below (**Table 9**).

Comparison	Definition
Best in class	Compare the building to the best performing building in a population of buildings with similar characteristics.
Average	Compare the building to the average performance of buildings in a population with similar characteristics.
Baseline	Compare the building's performance to its historical performance.
Performance standard	Compare the building to a clearly defined performance standard, such as those established in building energy codes.

Table 9: Common benchmarking comparisons (U.S. Department of Energy, 2011)

3. **Analysis and Evaluation Process.** Once all the data is collected, it can then be analyzed in order to understand the factors of performance and determine preliminary action steps (Energy Star, 2013). The staff performing the data analysis should:
    a. Identify peaks and valleys of consumption.
    b. Determine causes of fluctuations in consumption.
    c. Determine where gaps in data can be filled.
    d. Establish what is consuming the most utilities (i.e.: electricity).

Once the analysis has been completed, the IAIA can then move onto creating an action plan.

Step 3: Create an action plan for the retrofit.

The action plan should show how the IAIA's goal for improving the building's performance will be achieved (U.S. Department of Energy, 2011).

The key aspects of an action plan are as follows (Energy Star, 2013):

- Gaps in energy efficiency should be identified.
- Action steps to upgrade the building should be developed.
- Each action steps should have its own individual timeline and progress tracking.
- Information on all contractors and companies utilized should be included.
- What each contractor and company is providing should be documented.
- Dependence on consultants and outside providers should be determined.
- Standards should be set for potential contractors.

Step 4: Implement the project.

The AERG recommends three approaches for implementing projects that may be combined (U.S. Department of Energy, 2011):

- **In-House Implementation:** The in-house approach appears to be the lowest out of pocket cost option for energy projects and utilizes the facilities maintenance staff to install the improvements. These installments would be done on top of the maintenance staff's normal work.
- **Design-Build:** This approach is really a turnkey project that has all the design and construction done by a single contractor (U.S. Department of Energy, 2011).
- **Design-Bid-Build**: This approach is for new buildings and deep retrofits. A design firm creates bidding documents that are delivered to construction firms. These construction firms bid on the project, and the IAIA can choose the firm they will use.

Step 5: Evaluate the project and recognize goals that were achieved.

Following implementation and inspections, M&V can be used to measure, compute, and report the results of the improvements (U.S. Department of Energy, 2011). Through providing metering for the IAIA, the IAIA can utilize these meters to view accurate results of an upgrade. This information can then be shared with stakeholders to potentially celebrate success and encourage future renovations. Additionally, the IAIA should to provide internal recognition to the accomplishments of teams and individuals.

5.4 Recommendation 4: The IAIA should consider other devices that reduce gas and water usage.

In undertaking retrofit renovations, there is much more that can be considered than just changing lightbulbs. Other utilities can be optimized through the use of energy savings devices. These devices can greatly increase cost savings, and as such, the team recommends that the IAIA consider them in future deep retrofits.

5.4.1. HVAC

The majority of a building's energy consumption is due to heating, ventilation, and air-conditioning (HVAC) system. The two primary services of HVAC systems are to control occupant thermal comfort and ventilation. Centralized HVAC systems can be divided into two main categories: 1) the HVAC equipment, which consists of the boilers, chillers, air handlers, etc., and 2) the distribution system, which is primarily the piping, ductwork and terminal units.

Energy savings can be found in:

- upgrading to more efficient equipment
- minimizing HVAC run time
- performing routine maintenance on existing infrastructure

HVAC technologies that should be considered for increasing savings are:

- devices that widen the zone temperature "deadband"
- economizers
- demand-controlled ventilation
- high-efficiency systems
- smart systems for controlling temperature and run time

5.4.2. Plumbing

Water usage should be reduced not only to conserves resources, but also to preserve the infrastructure of the utilities themselves. The water in Santa Fe, New Mexico is "hard" (**Figure 27**), where the water contains a substantial amount of dissolved minerals such as calcium and magnesium (U.S. Geological Survey, 2013).

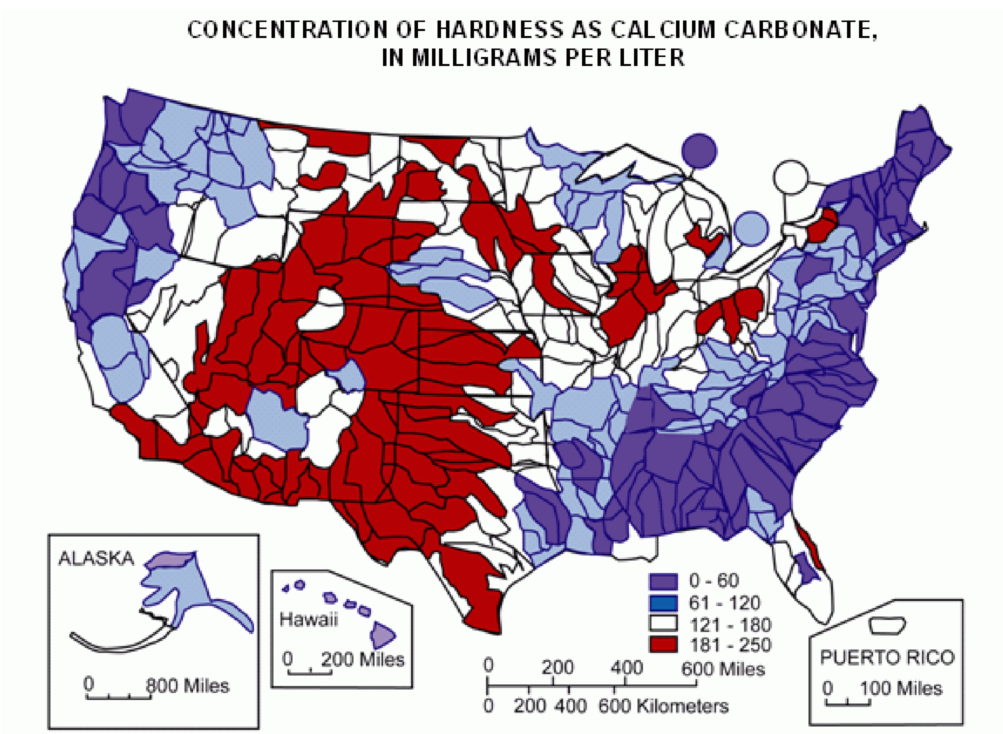

Figure 27: Water hardness concentration in the U.S. (U.S. Geological Survey, 2013)

These minerals are typically not a health concern, but they can cause mineral build-up in plumbing, fixtures, and water heaters requiring additional maintenance. In addition, hard water results in the excess use of chemicals and detergents to clean appliances.

Devices that should be considered for reducing water consumption are:

- utility sensors (i.e.: motion activated sinks)
- waterless urinals
- low-flush utilities

5.5 The IAIA should establish a revolving fund and explore other options to finance retrofit projects.

Due to the heightened price of deeper retrofits, all funding options should be considered by the IAIA. The team recommends strongly that the IAIA establish a revolving funding with the savings they find from retrofits into other projects. With that in mind, the team sought to understand how investment analysis can lead to this revolving fund, as well as exploring other funding options available to the IAIA. This recommendation is explained in detail, which account for its length.

The four funding topics detailed in this recommendation are:

- establishing a revolving funding
- various purchase options
- utility and government incentives
- selecting an investment analysis tool

5.5.1. Establish a Revolving Fund

Our team strongly recommends that the IAIA establish a revolving fund to reinvest savings from energy retrofits back into this energy saving program. If the IAIA implements an energy retrofit and it proves to work, such as the proposed LED lighting upgrade, then the institution should use the savings to outfit an additional building with LED lighting or some other efficiency measure. If a project proves to be successful, then it should be implemented into another building so that the savings can be realized throughout the campus. As the savings grow and this fund grows larger, the IAIA will be able to continue to purchase additional upgrades and work towards becoming a carbon neutral campus.

5.5.2. Purchase Options

Cash

The simplest form of payment for an energy efficiency project is cash. The IAIA does not have quite the cash reserve or balance sheet that other large businesses and institutions can tap into so this form of payment may not be the most viable option. However, cash is generally more appropriate for relatively inexpensive projects, so there may be certain energy efficient improvements with fast paybacks that the IAIA can look into. This form of payment may be considered depending upon the project's scale. Large and complex projects are best funded with debt or off-balance-sheet financing (ENERGY STAR, 2008).

Loans

Bank loans are a potential option for larger projects requiring equipment purchases. A loan for a non-profit organization could be a viable option when providing solid credit history information and reputable data from an energy audit regarding guaranteed savings to ensure there will be cash flow, which can be used to pay back the initial investment. An equipment loan will typically require a down payment of 20-25% of the project cost, so the IAIA should consider whether the immediate savings can justify the project cost (Energy Star, 2008).

5.5.3. Utility and Government Incentives

Utility and Energy Services Company (ESCO) Financing

Retrofitting projects can be paid for through on-bill financing where the provider fronts the cost for the investment and then receives a certain portion of the utility charge. The concept is somewhat similar to an ESCO where the investor fails to see any real savings from the project as the "savings" will be reimbursed to the provider to pay the cost of the retrofit (Energy Star, 2008). This can be a useful form of payment for larger projects within the IAIA buildings because economic savings are not the primary goal of the institution when it comes to lowering their carbon footprint.

Grants

Grants can cover a fraction of the project or the entire project cost. The team recognizes that the IAIA almost exclusively funds large projects through grants (Mason, 2016). Therefore, the IAIA should search for grants when planning future deep retrofits. For example, the IAIA could apply for a grant that would fund a project involving outfitting the Academic Building with occupancy sensors. The chances of the grant being approved will increase as they provide reputable information involving project costs, payback periods, potential savings, and a strategy for implementation.

5.5.4. Selecting an Investment Analysis Tool

Should the IAIA pursue the creation of a revolving fund, the model of investment analysis should be carefully selected. Three investment analysis tools the team recommends are (**2.4.4. Investment Analysis**):

- simple payback period
- net present value
- internal rate of return

5.6 Students enrolled in the sustainability class at the IAIA should aid in data collection.

With the creation of the Lighting Inventory Spreadsheet, the IAIA gained a tool which they can utilize for data collection. The spreadsheet currently contains information on the AB and the Foundry, including an accurate count of the lights in each building. However, the process of collecting all of this data among our three WPI team members was time-consuming. To shorten the process of inventorying, the IAIA should ask the students taking the IAIA's sustainability class to aid in creating accurate inventories of the other buildings on campus.

Students at the IAIA are aware and interested in making the IAIA's campus more environmentally friendly (Mason, 2016), so allowing them to aid in a part of the retrofitting process would help them to understand concepts and practices behind energy sustainability and this spreadsheet. The students would need to determine the number of each individual light type and operating hours of the rooms. This information, once collected and put in the spreadsheet, will provide Mr. Mason with information to determine which of the buildings should be updated next.

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ACRONYMS

AASHE – Association for the Advancement of Sustainability in Higher Education

AB – Academic Building

ACUPCC – American College & University Presidents' Climate Commitment

AERG – Advanced Energy Retrofit Guide

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

BOMA – Building Owners and Managers Association International

CA-CP – Clean Air-Cool Planet

CAP – Climate Action Plan

EIS – Energy Information Systems

HVAC – Heating, Ventilation, and Air-Conditioning

IAIA – Institute of American Indian Arts

IEA – International Energy Agency

IRR – Internal Rate of Return

LEED – Leadership in Energy and Environmental Design

LIS – Lighting Inventory & Analysis Spreadsheet

M&V – Measurement and Verification

NPV – Net Present Value

PNM – Power New Mexico

USGBC – U.S. Green Building Council

APPENDIX A

This appendix contains the bill of materials as well as the quote information the team received from Leviton for metering.

LEVITON

Bill of Material# 211656196 - D2

Worcester Polytechnic Institute Meters

Worcester, MA

Monday, March 28, 2016

This Bill Of Material is Based on a list of equipment received 3/28/16

ITEM	QTY	PART NO.	DESCRIPTION
1.00	2	2K208-08W	**Metering Solutions Kit** Series 2000 Meter Kit, Indoor Surface Mount, 120/208V, 3ø4W, Max 800A, 1.0kWh LCD Display Counter with 3 Split Core CT's
2.00	1	2K208-12W	**Metering Solutions Kit** Series 2000 Meter Kit, Indoor Surface Mount, 120/208V, 3ø4W, Max 1200A, 1.0kWh LCD Display Counter with 3 Split Core CT's
3.00	2	A8812-000	**Metering Solutions** Energy Monitoring Hub, 8 I/O, Surface Mount, Non-Configured ***Note: Building Manager Online 2.0 (BMO 2.0) energy monitoring software is included.***
4.00	1	00ECO-000-010	**Field Services** Measurement and Verification Engineering Services for LES M&V Products: Project Must be authorized by Design Assist Team (DesignAssist@leviton.com) prior to order or order will be refused. System Check-Out, Commissioning and Training by a Factory Authorized Engineer. **Engineering Services require a minimum of three (3) weeks advance notice.**

QUOTATION

dealers electrical supply
an employee owned company
2815 INDUSTRIAL ROAD
SANTA FE NM 87507-3119
PHONE: 505-471-2131
FAX: 505-471-2192

Quotation # 3747448-00
Customer P.O.# LEVITON METERING
Customer No. 883703
Quotation Expires:

To:
CASH SALE

WORCESTER POLYTECHNIC INSTITUT
SANTA FE NM

Ship To:
CASH SALE

SANTA FE NM

Date	Ship Via	Salesman	Tax Code	Terms
03/23/16		3701	37	NET

Line	Quantity Required	Item Number	Description	Unit Price	U/M	Amount
1	2	LOT	LEVITON 2K208-08W SERIES 2000 METER KIT, INDOOR SURFACE MTD, MAX.800A 1.0KWH LCD DIPLAY COUNTER W/3 SPLIT CORE CT'S	699.550	E	1399.10
2	2	LOT	LEVITON A8812-000 ENERGY MONIT ORING HUV,8 I/0,SURFACE MOUNT NON-CONFIGURED. NOTE:BUILDING MANAGER ONLINE 2.0(BMO2.00 EM	1475.000	E	2950.00
3	1	LOT	LEVITON 2K208-12 SIERES 2000 METER KIT , INDOOR SURFACE KIT 1200A MAX 1.0KWH LCD DISPLAY COUNTER , W/ 3 SPLIT CT'S	699.550	E	699.55
4	1	LOT	LEVITON FEILD SERVICES: MEASUR EMENT AND VERIFICATION ENG. SERV. FOR LES M&V	2006.250	E	2006.25
			SUB-TOTAL			7054.90
			SALES TAX			586.47

SIGNED BY: [signature]

Total >>> 7641.37

Bill of Material# 211656196 - D3

Worcester Polytechnic Institute Meters

Worcester, MA

Friday, April 01, 2016

This Bill Of Material is Based on a list of equipment received 3/28/16 and 3/31/16

ITEM	QTY	PART NO.	DESCRIPTION
1.00	2	2K208-08W	**Metering Solutions Kit** Series 2000 Meter Kit, Indoor Surface Mount, 120/208V, 3ø4W, Max 800A, 1.0kWh LCD Display Counter with 3 Split Core CT's
2.00	2	2K208-12W	**Metering Solutions Kit** Series 2000 Meter Kit, Indoor Surface Mount, 120/208V, 3ø4W, Max 1200A, 1.0kWh LCD Display Counter with 3 Split Core CT's
3.00	1	A8814-163	**Metering Solutions** EMH+ Data Acquisition Server with 3 Phase Meter Includes 1600A CTs, Power Supply
4.00	2	A8812-000	**Metering Solutions** Energy Monitoring Hub, 8 I/O, Surface Mount, Non-Configured ***Note: Building Manager Online 2.0 (BMO 2.0) energy monitoring software is included.***
5.00	1	00ECO-000-010	**Field Services** Measurement and Verification Engineering Services for LES M&V Products: Project Must be authorized by Design Assist Team (DesignAssist@leviton.com) prior to order or order will be refused. System Check-Out, Commissioning and Training by a Factory Authorized Engineer. **Engineering Services require a minimum of three (3) weeks advance notice.**

QUOTATION

dealers electrical supply
an employee owned company
2815 INDUSTRIAL ROAD
SANTA FE NM 87507-3119
PHONE: 505-471-2131
FAX: 505-471-2192

Revision III

Quotation # 3747448-00
Customer P.O.# LEVITON METERING
Customer No. 883703
Quotation Expires:

To:
CASH SALE

WORCESTER POLYTECHNIC INSTITUT
SANTA FE NM

Ship To:
CASH SALE

SANTA FE NM

Date	Ship Via	Salesman	Tax Code	Terms
03/23/16		3701	37	NET

Line	Quantity Required	Item Number	Description	Unit Price	U/M	Amount
1	2	LOT	LEVITON 2K208-08W SERIES 2000 METER KIT, INDOOR SURFACE MTD, MAX.800A 1.0KWH LCD DIPLAY COUNTER W/3 SPLIT CORE CT'S	699.550	E	1399.10
2	2	LOT	LEVITON A8812-000 ENERGY MONIT ORING HUV,8 I/0,SURFACE MOUNT NON-CONFIGURED. NOTE:BUILDING MANAGER ONLINE 2.0(BMO2.00 EM	1475.000	E	2950.00
3	2	LOT	LEVITON 2K208-12 SIERES 2000 METER KIT , INDOOR SURFACE KIT 1200A MAX 1.0KWH LCD DISPLAY COUNTER , W/ 3 SPLIT CT'S	699.550	E	1399.10
4	1	LOT	LEVITON A8814-163 EMH+ DATA ACUISITON SERVER W/ 3 PHASE METER , INCLUDES 1600A CT'S	1466.250	E	1466.25
5	1	LOT	LEVITON FEILD SERVICES: MEASUR EMENT AND VERIFICATION ENG. SERV. FOR LES M&V	2006.250	E	2006.25
			SUB-TOTAL			9220.70
			SALES TAX			766.52

SIGNED BY: [signature]

Total >>> 9987.22