Campus Energy
Action Research Team 2012

Leaders
Wendy Greene
Kyle Graycar

Members
Anjana Amirapu
Rachel Woods-Robinson
Allison Clark

Stakeholders
Jonathan Smithers
Shawn Cun

Table of Contents

Section 1: Executive Summary

As the Campus Energy Action Research Team, our mission was to monitor campus energy usage and to devise ways to reduce usage. Our original stakeholder, Nurit Katz, referred

us to Jonathan Smithers and Shawn Cun of Facilities Management. Jon suggested Engineering IV as a project focus due to its high number of corridors, old infrastructure, and high foot traffic.

Through talks with our stakeholders and team members, the Corridor Lighting Assessment Project (CLAP) was born. The goal of CLAP was to manually measure how much energy was being used to light the corridors of Engineering IV. We would then devise the best possible method to reduce energy use; options included removing a single bulb from each unit, lighting only every other fixture, or changing the type of bulb used. We discovered that the corridors were far overlit and that the most financially viable and energetically efficient option would be to replace bulbs with newer, more sustainable bulbs. Jon suggested that replacing all bulbs, currently 28-watt, with 25-watt bulbs. Such bulbs would not decrease the lighting drastically but would consume much less power.

One of our members proposed a second project: the construction of a solar panel. We ordered a build-it-yourself solar panel kit online and constructed it as a team. This was a great educational experience for all involved. We also used the panel at the Earth Day Fair to power blenders to make smoothies and found that there was great public interest in solar technology. This led us to join BGreen's Green Solutions Competition, in which we proposed ordering three Solar Dok charging stations to install on the UCLA campus. We placed second in the competition and hope that this proposal can be used during the next school year to receive funding and serve as a focus for a future ART team.

Section 2: Overview and Public Goals

Our team's concentration was energy consumption, a field that can cover many practices. We decided to narrow our focus to lighting, the most accessible and visible of the university's power consumption. We were particularly interested in assessing corridor lighting because of its uniform nature and high energy usage. The original plan was to monitor lighting levels in as many on-campus buildings as possible and implement changes to lower power use. However, in order to implement the best and most efficient change, we eventually narrowed our focus to the Engineering IV building as per the recommendation of our stakeholder. Thus, the CLAP project was established. CLAP aimed to reduce corridor lighting energy consumption from a tangible, student-initiated result.

Light levels were measured using the Extech 401027 Footcandle Meter, which were then compared with the standard corridor level requirement of 5-15 footcandles (a non-SI unit of measurement for light). One footcandle is the illuminance on a one square foot area. This information would be used to deduce what change we would implement within Engineering IV. During our first data collection, the team went through each corridor in the building and took measurements. Our information showed averages far higher than the maximum requirement of 15 footcandles (refer to Data Analysis for more detail). Without our ART team, this unnecessary consumption would not have been noticed.

After presenting this information to Jon, he suggested different methods that could be used to decrease corridor brightness. We had meetings nearly every other week and learned the technological aspects of the fixtures, interpreted our numbers, and discussed potential procedures. Because of the constant activity within Engineering IV's corridors, motion-sensing lights were not considered a priority. Jon also noticed that the bulbs being used in the

laboratories were very old and inefficient and brought this up with Facilities. If not for the ART team's project, this fact would have been overlooked.

In the beginning of spring quarter, Jon found documents containing relevant information on lighting from an old 1993 contracted assessment. Due to conflicts with corridor number designations, we decided to do a second full data collection of the building's lights. We also remeasured because we believed we would be able to get more accurate numbers due to our increased familiarity with the meters and our knowledge of what mistakes were made during the first run-through. Rather than collect a few measurements in each corridor, we measured the levels between each fixture and the next and labeled corridors according to the 1993 floor plan.

All bulbs in the Engineering IV fixtures had been 28-watt. It was decided that replacing these bulbs with more efficient 25-watt bulbs would have the most benefits regarding energy savings, cost, and labor. Using older and existing numbers, Jon was able to compile a file (included in this report) with information on how much energy and money would be saved once this change was implemented. The information gathered from the CLAP project will help Facilities Management retrofit Engineering IV, thus reducing UCLA's overall energy use and expenses. We also believe that our project will set the precedence for future lighting projects by the ART program. Meters will be left with ESLP to help support these assignments.

Our second major project was facilitating the installation for solar charging stations on campus. We wanted the UCLA community to be able to charge their small electronics through these stations. The main goal for implementing these stations was outreach: to educate the public on how electricity is generated from solar panels through a hands-on approach. We also wanted

to encourage sustainable everyday habits by giving the UCLA community greater access to alternative energy for daily activities, such as phone and laptop charging.

Our inspiration for the stations came from our team building the solar panel that is currently on the IoES patio deck. It was done through an educational do-it-yourself project for us to understand how electricity was generated from solar panels. Through this process we learned that solar power, and even other forms of alternative energy, were very accessible. Our panel inspired us to share this idea of solar energy directly with the public. We wanted them to be able to interact with solar energy in the same way we could.

We solidified our plan for installing solar charging stations through the BGreen Green Solutions Competition, in which we were awarded second place. As we mentioned in our business proposal, we plan on purchasing three Solar Doks, a patio table-themed charging station from EnerFusion, Inc. EnerFusion and ASUCLA are very enthusiastic and interested in our project and we already have very close connections with them to more efficiently implement these stations. We plan on finalizing locations for the stations with ASUCLA in the fall of 2012, apply for The Green Initiative Fund in winter of 2013, and then construct and implement the panels by the spring as an Action Research Team.

Our larger goals for implementing these stations is that UCLA will be the first school on the West Coast to have these stations, so we will set a precedence for other UCs and even non-academic establishments. In addition, these initial stations can be used as tests to gauge the interest of students in solar energy. If successful, UCLA could even implement more charging stations through student and faculty efforts.

Section 3: Significance and Background

Prior to our project, UCLA had a range of interest in renewable energy and energy conservation. However, no group had concentrated on the specific aspects that we focused on. Facilities Management has been updating lighting in the buildings on campus for years, but very few hands-on surveys were conducted. Our team came across a 1993, campus-wide survey, which we used in our analysis, but unfortunately there is no electronic form of the data and it had been overlooked for years by Facilities Management.

Recently, there has been a surge of complaints from professors and members of the UCLA community about excess lighting on campus. UCLA Professor Ben Zuckerman published an article in the Daily Bruin focusing on the LEED Certified Terasaki building, where he had noticed bright lights on at all hours of the day. In response, Green Campus, a program that works to reduce energy use on campus, piloted a lighting audit project in the dorms. However, no group before us had done a footcandle analysis on a UCLA building, not to mention a corridor specific analysis.

Our CLAP project aimed to reduce energy use by determine specifically where we can use less light. We focused on Engineering IV, using procedures that can be directly applicable to other buildings on campus. Lighting accounts for a huge amount of energy use at UCLA, so a reduction of excess lighting would drastically reduce our energy costs and demands.

Additionally, our team was surprised to find that UCLA, located in one of the sunniest areas of the country, uses very little solar energy. Los Angeles as a whole lags behind other cities, such as Berlin, Germany, with a far lower solar flux. UCLA also falls behind many other universities, particularly those in Washington, the Midwest, and the East Coast, all of which are exposed to less sun. Although we do have our Co-Generation plant, which uses natural gas and captures excess energy at 80% efficiency, we thought it necessary to consider the presence of solar energy on campus.

The 2011 UC Annual Report on Sustainability Practices aimed to create a plan to generate 10 megawatts of onsite renewable energy on UC campuses by 2020. We can account for only a tiny portion of these megawatts. Recently, UCLA has been taking steps toward the direction of installing more solar energy. BGreen Consulting, the group that organized our business proposal competition, is in the final stages of installing solar panels on Ackerman Student Union. However, this is an ASUCLA building; there are no solar panels installed yet on any UCLA building. We realized that it would not be practical in our team's timeframe to push for solar panels on a building, so we aimed for a smaller, more specific goal: the Solar Dok. Currently, the Solar Dok is installed at Vanderbilt University and several other universities on the East Coast and Midwest. When we install it at UCLA, our university will be the first on the West Coast to have a solar powered charging station for small electronic devices. Although these stations will account for only a fraction of UCLA's energy expenditure, they will serve as a catalyst in the awareness and future implementation of renewable energy on the UCLA campus.

Section 4: Initial Conditions

Our team, originally the Energy Assessment ART, was the first of its kind and thus had flexibility in determining our projects and deciding which direction we wanted to take. Although we did have the "HEMP" project from last year's ART team, it was more heavily focused on the dorms and less on energy savings on campus.

Initially, we spoke to our stakeholder, Jonathan Smithers, in the facilities office. He stated that the most helpful project for him would be an energy assessment of Engineering IV. Throughout the project, we discovered that the lighting was incredibly outdated, which led the facilities office to begin a renovation of the entire building. Through this process, we had to purchase our own light meters through the ART program as well as request blueprints of the Engineering IV building from the facilities office. Hopefully, the data that we compiled can be used for future ART teams as a building block for assessing additional campus buildings.

For our solar panel project, we again started with a simple idea of educating ourselves on solar panels. To our knowledge, no other ART team had done anything similar, which made it a unique experience. One of our group members, Rachel, had some connections with the campus renewable energy community and initiated the "solar smoothie" idea for Earth Day, which turned out to be a very successful means to generate student interest in renewable energy on campus. Afterward, we continued the solar project through a campus sponsored competition, which has turned into a larger goal of implementing solar charging stations on the UCLA campus.

Although our team had relatively little to work with in terms of a previous ART team, we were able to successfully form two separate projects, and both of which have been incredibly successful.

Section 5: Research Methodology

For CLAP, we used lighting meters to measure the lighting levels of the corridors in Engineering IV. These meters were funded by the IoES' D'art Fund. These meters are essentially a small electronic device with a smaller bulb-like surface piece attached via a wire. The bulb surface of the smaller piece was placed on the ground between two fixtures upward to expose it to the light. The number designating the strength of the light is displayed on the device, which we documented during our run-throughs. Lighting data totals were collected in two separate trials. Our first trial gave rough estimates of levels. Our second trial, however, gave more accurate results for two reasons. Firstly, the levels between every fixture in the building was measured. This differed from the methodology applied in the first test in which we only measured a few times per corridor. Secondly, we were more knowledgeable of how to work the devices and were better with estimating the middle locale of each pair of fixtures, giving less skewed results.

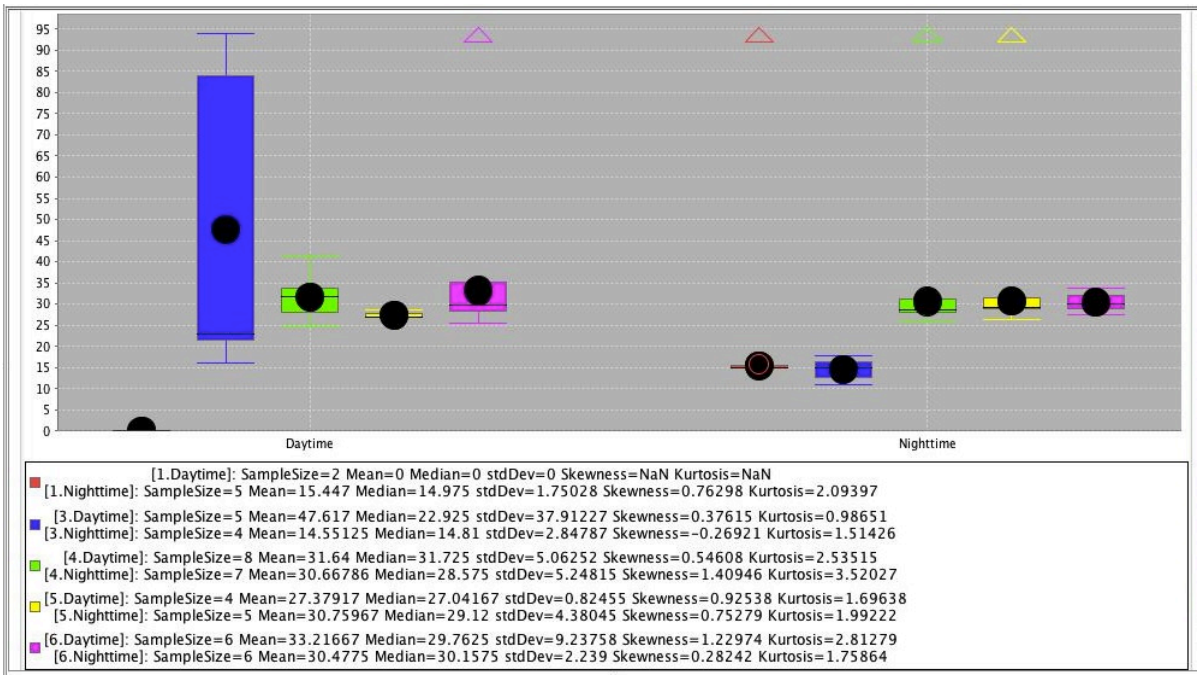
The numbers collected from the second trial were then sent to Jon, who estimated how much energy was being used for these levels to be maintained in the building. He also calculated the power that would instead be used if these bulbs were replaced according to our plan (refer to Data Analysis section). This saved energy was also translated to financial savings for the university.

For our solar panel project, we researched which panel had the potential to power small electronics such as cell phones and laptops. We also did research on batteries that would work best to power the panel. We decided on a SunForce 60-watt panel and marine battery (car battery). The panel and battery were both covered by Dart funds. For our business proposal to having Solar Dok stations installed on campus, we surveyed students (both online and in person) to gauge interest in the project. Our survey consisted of three questions and a comment section. Questions included whether students would like to see such stations on campus, what electronics they would be charging, and what locations they would like to see the stations. A total of 160 students were surveyed. Part of collecting this data included asking people in front of the South Campus Student Center while having our panel on display, charging the laptops with the surveys on them.

Section 6: Data and Cost Analysis

Data Analysis of Corridor Lighting Assessment Project:

Engineering IV houses 2100 4-bulb fixtures. The ideal light intensity levels for corridors falls between 5 and 15 footcandles. From our initial assessment of Engineering IV, we immediately discovered that the levels for the facility were well above this range. Average intensity levels (without daylight interference) was 24 foot candles, almost five times more than necessary. Please refer to our appendix for additional spreadsheets and information.



These box plots were constructed using the corridor means as the X sample statistic, to demonstrate a visual of an estimation of the actual average corridor intensities for the floors on Engineering IV. The sample data used in these plots were used from our first assessment of the building. The large standard deviation on 3rd Floor Daytime (Left blue) can be attributed to windowed areas with high natural light exposure. From the chart, it is apparent that many of the floor means, for both day and night recordings, are above the necessary footcandle levels.

After conducting this initial assessment, we conducted a more thorough assessment of Engineering IV at nighttime (to eliminate daylight interference) in Spring Quarter. Below are the average light levels for each hallway in Engineering IV. Please see the attached Excel spreadsheet for additional depth.

HLWY	Mean (footc)	#Fixt.	#Bulbs
1S10	35.15	4	4
1S14	16.5	10	2
1S19	18.3	5	2

1N31	18.9	5	2
1N35	11.75	3	2
1N1	43.2	4	4
1N22	17	*	*
1N15	16.0	7	2
1S37	15.8	6	2
1S9	20.2	6	2
1S1	49.7	4	4
2S10	15.16	5	2
2S30	16.2	5	2
2S25	16.1	5	2
2N30	12.9	5	2
2N6	15.9	5	2
2N14	15.9	14	2
2N18	15.7	10	2
2S42	15.4	6	2
2S7	18.9	10	2
3S30	28.8	7	2
3N26	33.7	3	2
3N25	32.1	5	2
3N40	29.725	7	2
3N6	32.15	5	2
3N1	50.1	3	4
3N12	28.83	11	2
3N19	28.5	7	2
3S37	28.2	6	2
3S7	33.2	10	2
4S30	30.4	6	2
4N26	30.4	3	2
4N25	28.0	4	2
4N37	23.8	4	2
4N7	26.2	6	2
4N1	44.1	3	4
4N11	30.3	12	2
4N19	30.3	7	2

4S39	27.7	6	2
4S7	33.4	*	*
4S1	83.9	3	4
5S28	29.6	6	2
5N29	29.7	3	2
5N38	33.1	4	2
5N42	25.4	4	2
5N6	28.0	5	2
5N1	44.9	3	4
5N15	27.3	11	2
5N19	27.9	7	2
5S37	28.7	6	2
5S7	31.4	11	2
5S1	81.6	3	4
5S2	27.3	2	2

The hallway number, number of fixtures, and number of bulbs were found from the 1993 contracted lighting assessment of Engineering IV (See Background). The cells marked with an asterisk lack information because of a fault transposing the old spreadsheets from text into digital format. This table confirms our original assessment, with more accurate figures. Almost all of the hallway averages above are well above the preferred light intensity.

In general, fluorescent lamps typically have a rated life of about 20,000 hours. In reality, they require replacement at around 17,000 hours. Because these lamps are in corridor light fixtures, they operate constantly, an estimated 8,760 hours/year. Thus, on average the lamps need to be replaced about every 2 years. Lamp replacement costs will be around $4.00/lamp for materials and around $3.00/lamp for labor. The total maintenance cost for a 4-lamp fixture would thus be: 4 lamps x $7.00/lamp/2-years = $14.00/year.

Data and Cost Analysis of Do-It-Yourself Solar Panel Project:

Our Sunforce 60W panel was purchased from Amazon.com for $275. The funds for this project were allocated through Dart funding. The $108 marine lead-acid battery for the panel was also acquired with Dart funding.

A cost analysis has already been conducted for the three solar charging stations we would like to install in the next academic year. Each product costs $10,495 per station, with $3,900 for shipping and installation fees. We hope to acquire these funds through TGIF, and plan to apply for the winter proposal process. Please see our attached business proposal for additional cost information. For our business proposal we also conducted a survey to gauge student interest. Below is a table demonstrating where students would prefer to see these stations located.

	1	2	3	4	5	Rating Average	Response Count
South Campus Bombshelter	**56.2% (86)**	12.4% (19)	11.1% (17)	6.5% (10)	13.7% (21)	2.09	153
Lu Valle Commons	3.2% (5)	11.0% (17)	15.6% (24)	**50.0% (77)**	20.1% (31)	3.73	154
Ackerman outdoor eating area	14.9% (23)	30.5% (47)	**39.6% (61)**	10.4% (16)	4.5% (7)	2.59	154
Kerkhoff patio	20.1% (31)	**39.0% (60)**	26.6% (41)	9.1% (14)	5.2% (8)	2.40	154
North Campus Student Center	5.8% (9)	7.1% (11)	7.1% (11)	24.0% (37)	**55.8% (86)**	4.17	154

Section 7: Key Findings

Corridor Lighting Assessment Project:

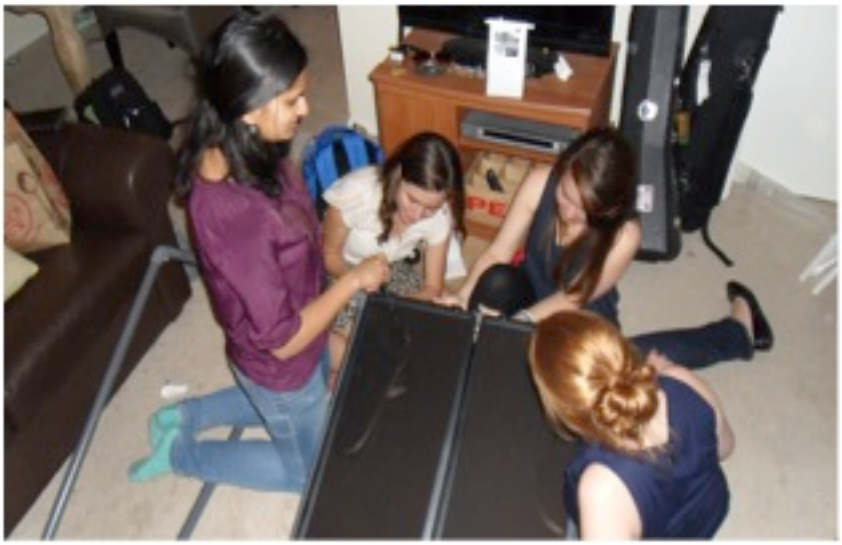
We found out how much light energy was being wasted to light the corridors of Engineering IV via light sensor recording on the field. This gave Facilities Management the momentum to begin planning its retrofit of the building. This retrofit, which is set to begin this summer and involving the replacement of inefficient bulbs, will return an estimated $30,000-40,000 in energy savings every year. This will return cost of the retrofit in 2 years. From just corridors alone, our stakeholder calculated a total of $4,238/year and 46,568kWh/year of savings from a retrofit that includes exchanging for more energy efficient bulbs and even removing bulbs where they are not necessary (see attached “Engineering IV Corridor Intensities_Savings Est.xls”).

Through our experiences at Engineering IV with Jon Smithers, we learned a lot about facility lighting techniques and the process for assessing lighting situations. There are many subtle nuances to corridor lighting that we did not anticipate until we began our field research. For example, we did not realize how significant daylight would be on our metrics. We also are now knowledgeable of some of the inner processes within Facilities Management, and have established a solid relationship with our stakeholders there.

Do-It-Yourself Solar project:

We learned a lot about solar energy, in particular the technical details about solar panel construction. This project initially started purely as an educational one, but we then discovered very relevant aspects of solar energy that we hoped to share with the UCLA community via tabling with our panel and proposing solar charging stations.

This led us to our discovery that there is indeed a deep interest in renewable energy implementation on campus. This can be seen from the student survey we conducted and in our success placing second at BGreen's Green Solutions Competition. The operation plan has already been established for how next year's Campus Energy ART team can implement the EnerFusion Solar Dok stations (see attached business proposal for additional information).



Section 8: Recommendations

Our analysis has established the precedence for next year's Campus Energy ART team. Additionally, several of our members plan to continue as this team to raise funds and install the three Solar Doks. These projects in particular have a huge potential for energy and monetary savings on campus. Our business proposal provides a step-by-step plan for next year. Having already established conversation with Karen Noh at ASUCLA, we will, under her guidance, apply for funding through TGIF in winter to purchase three Solar Doks by winter quarter of 2013. Simultaneously, we will work with ASUCLA and student organizations to determine variables such as station locations and transportation details. Once the Solar Doks are transported, the new ART team will help set them up and make the process a community effort. We hope that this project will bring about a change in mindset and a greater demand for renewable energy on campus. After the completion of the Solar Dok, we will be able to tackle other developing issues on campus related to renewable energy and energy conservation.

The Solar Dok project so far been independent of our stakeholder. Perhaps next year's Solar Dok ART team can work with Facilities or ASUCLA to implement the solar projects.

Our stakeholder, Jon Smithers, worked with us on the CLAP project. He was very helpful with data collection and analysis, and accompanied us to the Engineering IV building several times to provide background for our research. He was available during both quarters to answer our questions, and always responded in a reasonable timeframe. We have done our research, so it is now up to Facilities Management to implement retrofit changes. As a follow-up, a student

group or future Energy Assessment ART team should analyze lighting in other buildings to continue this process.

Section 9: Conclusion

Overall, our ART team has had an incredibly successful two quarters. Through our CLAP project and our solar panel project, we have created two long-term projects that will instate a great amount of change on the UCLA campus, both seen and unseen.

The Corridor Lighting Assessment Project completed by our ART team in tandem with Jon Smithers from the UCLA Facilities Office has turned into a full-scale lighting retrofit of Engineering IV. Initially, we took readings of the light levels in the corridors; however, upon further inspection of the exceptionally high levels of light in the hallways, Jon realized that the entire building had not been assessed on a professional level since 1993. Our ART team successfully updated the 1993 data to accommodate current light levels. From this data, Mr. Smithers determined that a retrofit of all of the lighting in the building, including corridors and inaccessible laboratories, was necessary. He has stated that he anticipates this retrofit will save the University nearly $45,000 each year and will pay itself off by 2014.

In initiating an entire lighting retrofit project, our ART group participated in a do-it-yourself solar panel project, where we built a 60-watt solar panel by ourselves. This project was an incredible learning experience, as we all got a hands-on approach to solar energy. While figuring out what we wanted to do with our completed solar panel, we decided to enter into a campus-sponsored business competition, in which we received second place. This competition inspired us to begin steps towards implementing three solar charging stations across the UCLA

campus, hopefully stimulating the campus community to discuss renewable energy and educating our peers and faculty on the benefits of solar power. This is a long-term project, and our group plans to continue to implement this during the 2012-2013 academic year. We have already established relationships with all necessary stakeholders, including the company from which we wish to purchase the panels, EnerFusion, Inc.

The Action Research Team program has been an incredible learning experience for our entire group. We are very proud of our accomplishments over the past two quarters, and we look forward to continuing some of our projects in the upcoming months.

Section 10: References

Jon Smithers, Facilities Management -- Assistance in CLAP Project.

Joe Kobus, President, Enerfusion Inc.

Tom Davis, Co-Founder, Enerfusion, Inc.

Darren Beville, Energy Manager, Vanderbilt University

Section 11: Appendix

Please refer to attached “Campus Energy ART files” folder for our additional work (Excels, papers, business proposal, presentation, etc.)