United States Department of Energy

Better Buildings Case Competition

Experimenting With Efficiency: Greening the Grant Process for Research Institutions

Executive Summary

This proposal describes the split incentive problem with university laboratories that use large amounts of energy but do not directly pay for their energy consumption. Currently, grant-funded researchers lack the incentive to purchase energy efficient equipment and prioritize energy saving behavior because their energy costs are covered through indirect Facilities and Administrative (F&A) cost agreements. The proposal presents solutions to synchronize the incentives of the major stakeholders to pursue energy efficiency improvements in user behavior, energy efficient building upgrades and the procurement of laboratory equipment.

The proposal puts forward the following recommendations to grant making institutions and the government bodies that implement policies regarding the research grant process:

- Invest in the research and development of a Labs21 computer application that integrates university energy data to monitor energy use, provide feedback and recommendations about energy management, and access best practice information.
- Require all recipients of research grants to establish monitoring and reporting programs for laboratory energy usage.
- Require energy efficiency standards for grant-funded procurement of laboratory equipment.
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The Labs21 application will provide an easy to use platform for energy monitoring on a campus, building and individual lab basis. Monitoring and understanding how energy is being used will 1) help users make more energy efficient choices 2) compile a robust energy use database that can be used to develop industry efficiency standards for labs and equipment 3) save grantmaking institutions money in the long run by reducing F&A costs.

In order to be eligible for federal grants, universities would have to install and update energy monitoring on a building and laboratory basis. Having energy monitoring in place will facilitate Universities to utilize the Labs21 app to implement a energy efficiency initiative. At our university, this initiative would include:

- Create monetary incentives for departments to facilitate energy efficient behavior in university laboratories.
- Create an Energy Sustainability Fund to provide money for energy efficient lab equipment upgrades and building infrastructure upgrades.
- Use the Labs21 computer application for the exchange and adoption of best practices

The recommended combination of federal policies and university-level incentive programs provides a synergistic approach to overcoming barriers to laboratory energy efficiency. The policy framework and monitoring technology will instigate adoption of an integrated energy incentive program. Implementing these recommendations will allow the federal government, universities, and researchers to capture the financial and environmental benefits of energy efficiency.

Introduction:
University campuses are very large and energy intensive. Laboratories are one of the largest energy users on university campuses, consuming 40-50% of the total energy use, even though they may occupy only 20% of the total floor space (BBCC, 2013). Significant reductions in energy consumption through energy efficiency measures in laboratories has a large potential for energy and monetary savings as well as CO2 emission reductions and climate change.

Currently, there are a few different obstacles to overcome when incentivizing energy efficiency in university laboratories. First, building users usually do not directly pay their utility bills, so they have little incentive to conserve energy. Second,researchers often focus their funds and time on their research, not energy efficiency. Third, there is limited funding for equipment and infrastructure upgrades. Finally, the knowledge about energy efficiency best practices that is available is sometimes scattered and/or inaccessible and current information about energy efficient lab equipment is insufficient to make informed purchasing decisions.

Federal Grant-making Recommendations:
Pursuant to Executive Order 13514 on Federal Leadership in Environmental, Energy, and Economic Performance, federal agencies must develop a sustainability plan that prioritizes actions with a positive return on investment for the American taxpayer that meet energy, water, and waste reduction targets. Energy efficiency in university laboratories accomplishes the dual goal of meeting reduction targets while saving the taxpayer money in the long term; reducing a university laboratory's energy usage reduces the amount of electricity that the federal government (Department of Health and Human Services) pays through Facilities and Administrative (F&A) Indirect Cost Agreements with a grant-awarded institution. The federal government can secure its leadership position in environmental performance by taking the following measures:

1. Require federal grant applicants to monitor and report laboratory energy usage
2. Invest in the research and development of a phone, tablet, and computer Labs21 application (app) that integrates energy monitoring.
3. Eventually, create and enforce efficiency standards for lab equipment purchased with federal grants.

In an effort to better develop and implement energy savings strategies, federal grant-making agencies should require grant applicants to monitor energy usage. Requiring monitoring and active energy management will be a crucial step in reducing both campus energy usage and the associated F&A costs for which federal agencies are responsible. The federal grantmaking agencies should create a transparent and feasible timeline for monitoring individual laboratory energy usage, with the eventual goal of requiring that all grant recipients monitor and report usage. The timeline should include an initial phase of installation of monitoring technologies, a phase of monitoring and reporting energy usage, a phase of using best practices to inform energy efficiency standards in university laboratories, and an ongoing phase of developing and pursuing energy reduction targets.

Once monitoring and energy efficiency standards are established, the university can quantify and evaluate laboratory energy savings opportunities, leading to lower F&A costs that save taxpayers

money in the long term. During the initial phase of implementing monitoring, federal grant agencies will end up paying for installing monitoring through increased F&A costs. However, F&A costs will eventually go down over time after monitoring systems are established and energy efficiency increases.

Energy consumption intensity varies significantly between different building uses. For departments that have low intensity energy consumption, building scale energy monitoring is sufficient and reporting for federal grant eligibility can be a building average (kilowatt/ft2). However, buildings that use energy-intensive laboratory equipment, such as science and engineering, would require more specific plug-load monitoring equipment (discussed below).

Eventually, when the Labs21 application (discussed below) is operational and there is sufficient data to populate the Labs21 Wiki database of energy efficient laboratory equipment, we recommend that the Department of Health and Human Services enforce Title 45 of the Code of Federal Regulations by requiring every equipment purchase by federal grant-making agencies to meet energy efficiency standards as determined by the Labs21 database, and requiring that energy efficiency information for lab equipment be included and evaluated in all procurement procedures. Currently, federal research grants directly cover the purchase of research equipment, and the Code of Federal Regulations states a preference for products that are energy efficient, but when a future grant application is approved based on scientific merit, HHS needs to take a more active role in supplying information regarding efficient equipment as well as enforcing the procurement of such equipment. When efficiency standards and procurement regulations are in place, the federal government will achieve substantial savings through lower F&A costs associated with efficient equipment while the participating universities capture a portion of those savings. We recommend that federal agencies effectively communicate their intention to increase university energy efficiency and allow adequate time for planning and compliance. It is equally important that agencies such as HHS communicate their ability and intention to enforce the proposed regulations.

The DOE:

In collaboration with the federal grant requirements to monitor energy use, we propose that the DOE develop and provide a Labs21 app that streamlines and integrates energy monitoring, best practice information and user interactions. This app will be accessible on a variety of devices including smart phones, tablets, and computers. The app will be the main platform for the DOE, university energy managers, building facilities managers and researchers to monitor energy use and share existing information on laboratory efficiency (Figure 3). The app will streamline how users receive information and integrates all the information available about best practices in an easily accessible user interface. Universities can sign up for the app and link all of their energy monitoring information to the application. Once lab managers and researchers download the app and input their university, building, and lab information, they will have access to real-time and historical energy consumption data and will be able to sync the app to integrate their laboratories' activities.

The main users of the app include:

- <u>DOE and Existing Information</u>: The DOE facilitates the creation of the app and incorporates existing information about best practices for laboratory energy efficiency.

Information for universities' energy use and individual lab monitoring will be used by the DOE to further evaluate and update best practice information and recommendations. For instance, energy use data for laboratory equipment will be automatically updated to the Labs21 Energy Efficient Laboratory Equipment Wiki. This data can then be used by researchers when selecting what equipment to buy and to create industry energy efficient equipment standards.

- University Energy Manager: The University Energy Manager is responsible for installing energy monitoring equipment on buildings and actively managing campus energy consumption. She will create a university profile for the app with relevant information such as price of electricity, location, size, etc. She is also responsible for coordinating education and outreach concerning energy monitoring. She can use information from the app to monitor, evaluate, and manage energy and best practices at her university.
- Department Chair/ Building Facilities Manager: The Department Chair and/or the Building Facilities Manager is responsible for inputting building specific information into the app to create an individual building profile that includes: age, total square feet, square feet for different uses, type of HVAC system, type of lighting, etc. In addition, he is responsible for making sure that the energy monitoring technology in his building and laboratories are installed and correctly synced with the Labs21 app. He can utilize energy use information from the app to improve energy efficiency in his building.
- Researchers: Researchers are able to select their building profile from their university and sync their laboratory activities with the app to observe real-time and historic monitoring of their building and laboratory equipment. Understanding how energy is being used in their labs will help increase energy efficient user behavior. The app will also provide recommendations for ways to improve their energy efficiency through building, equipment and research specific best practice information. Researchers can also use the app to see how similar labs from other universities are pursuing energy efficiency.

The main features of the app will include:

- Monitoring: The application has a dashboard of real time monitoring synced with the laboratory's and building's energy use. The dashboard can be customized to compare the building/lab's energy consumption to: baseline average historic rates; the university average energy consumption; and/or similar labs' from other universities energy consumption. The app will make the dashboard the default screen saver when the device is idle.
- Feedback: The app can provide feedback for the user by monetizing energy usage in real-time, giving warnings when energy use is abnormally high or low. It can also give feedback that compares an individual's energy use to similar labs across the nation. If energy use is above the industry standard, it could issue warnings such as "Warning! Your average energy use is 155% more than other Chemical Engineering Labs." Feedback settings will be customizable to suit individual monitoring needs.
- Recommendations: The app can give recommendations of different energy efficient behaviors and strategies to participate in based on user monitored energy use, research type, equipment type and other relevant information. Also, it can recommend effective behaviors undertaken by similar labs.
- Equipment Upgrades:

    - Includes information on estimates for how much energy could be saved by switching to different pieces of equipment, so researchers know which equipment upgrades will save the most energy.
    - The app will be linked to monitoring of equipment in individual labs to create a database that contains more specific energy use information for a variety of different types of laboratory equipment.
    - The app will be linked to the Labs21 wiki with a user-friendly interface, and any updates on Labs21 wiki will be directly updated to app.
- Return on Investment Information: Based on set parameters and use data, the app can determine ROI for various building/infrastructure/equipment updates.
- Maintenance Request forms and Applications: Request forms and applications can be accessed and filled out through the app and directly sent to the building facilities manager and/or the university's utility and energy services.
- Reporting Energy Use: The app will automatically produce quarterly energy use reports that will fulfill federal grant requirements.

University Energy Manager Recommendations:
The federal grant making requirements for energy monitoring and the Labs21 app will facilitate adoption of an integrated energy management initiative at the University level. To meet these new standards and encourage energy efficiency, as the University Energy Manager, we will enact a three part solution:

1. Create monetary incentives to facilitate energy efficient behavior in university laboratories. The department and/or lab will directly receive a check for ⅔ of the energy they save.
2. Create an Energy Sustainability Fund to provide money for energy efficient lab equipment upgrades and building infrastructure upgrades. Savings from reduced energy consumption will be used to pay back loans.
3. Education and outreach will facilitate users to adopt best practices. Utilizing the Labs21 application, users have an easy to use platform to monitor their energy use (through a dashboard like screen), receive feedback and recommendations about energy use, and access user specific best practice information based on building type, age and use.

Monetary Incentive Initiative:
In order to bridge the incentive gap between building users, who generally control electricity usage, and the university, which pays for electricity, we will implement a monetary incentive initiative on a university-wide basis. Departments will directly receive ⅔ of the energy savings they are able to achieve in their building compared to an established baseline rate. If more than one department occupies a building, they will share the ⅔ of the energy savings between the departments in the building based on the percentage of the building they occupy. The other ⅓ will go into an Energy Sustainability Fund (discussed below), which will be used to fund this initiative. Individual labs are also eligible if they engage in energy efficiency practices as well.The recipients can apply the money toward any departmental expenses, but will be encouraged to invest this money toward further energy efficiency initiatives.

To accomplish this, an in depth metering system will have to be in place across the campus. As previously stated, federal grant-makers require monitoring of buildings and laboratories for

researchers to be eligible for grants. The first step in establishing a monitoring system will be determining where historic metering data is sufficient to establish baseline energy consumption and install new meters and submeters where necessary. Priority for installing/updating meters will be for more energy intensive buildings such as engineering and science departments.

Baseline rates will be calculated using a minimum three-year average energy use of the building. By running statistical analyses and regressions for energy use based on outside ambient temperature, time of day, month of the year, and number of researchers, we will able to establish baseline rates while taking into account factors that will affect energy use regardless of individual user behavior. Baseline rates will be re-evaluated and adjusted every three years to assess changes in use, occupancy and energy efficiency goals. An initial improved energy efficiency goal to reduce baseline rates by 3% every three years will be established but is subject to review and adjustment.

During the initial phase of implementation, the department chair and/or facilities manager of a building are able to request additional funds to establish monitoring technologies such as submeters and energy management technologies. The department chair has an incentive to pursue monitoring technologies to make his department eligible/competitive for future federal grants and consequently more attractive to researchers. If building occupants use energy intensive laboratory equipment, the department chair can request similar funds from campus utilities services to install equipment plug in monitors to further monitor energy usage.

In addition to general building metering, panel sub-metering will be added/upgraded to buildings in order to get a more detailed energy use profile of the building. Circuit sub-metering on the main electrical panel will allow building wide energy use to be broken down into relevant categories such as Heating Ventilation Air Conditioning (HVAC), lighting, plug in loads, high voltage plug in loads as well as general spatial distribution for these categories (ex. 3rd floor hallway lighting). This detailed energy use data will be streamed to the Labs21 app where it will be compared to baseline rates to determine energy savings for departments.

Sub-metering will also distinguish user based energy savings from campus initiated (or from the Energy Sustainability Fund which is discussed below) building improvements. For instance, if the campus energy manager upgrades a ventilation system in a building to a variable air volume system with occupancy sensors, it would reduce energy use in the building by a significant amount. The overall energy use of the building would go down, regardless of user behavior in the building. By knowing how much energy is used by the HVAC system, the energy savings from the upgrade would be factored out before allocating savings to the building users.

For many buildings on campus, building metering and main electrical panel submetering will be sufficient. The department chair of the building will receive a payment for ⅔ of achieved energy savings that can be distributed to individual building occupants, used for building improvements or on other departmental expenses. Initially, there will be no penalty for going over baseline energy rates.

High energy use labs will have additional plug in monitors for laboratory equipment electricity loads. Utilizing wireless plug in monitors (such as the kill-a-watt P-3 which can wirelessly

monitor up to 8 plug in loads), individual equipment energy loads will be wirelessly uploaded to the Labs21 app. Through individual equipment monitoring, researchers will be able to better understand how electricity is being used in their lab and will directly receive ⅔ of the energy savings from reducing plug in load electricity consumption. This will be taken out of building energy savings before it is allocated to the department (Figure 2, B). For instance, if a researcher notices that the standby (when turned off but plugged in) power of their lab equipment is high, they could work with their facilities manager to install a switch to completely power off lab equipment when not in use. In addition, equipment energy data will be automatically updated to the online Lab21 Energy Efficient Laboratory Equipment Wiki. This will create more robust information to compare lab equipment energy efficiencies and create standards that can be used for future purchasing. Increased data and standards will put pressure on laboratory equipment manufacturers to increase the energy efficiency.

Energy Sustainability Fund:
Many of the energy inefficiencies experienced by laboratory buildings across the university campus are a result of inefficient/aging infrastructure and equipment. Major opportunities for energy savings in laboratory buildings are available through upgrades to HVAC systems, lighting systems and laboratory equipment. However, large upfront costs of such upgrades often present a major obstacle to researchers and university facilities managers. To help university facility and building managers move past the high upfront costs, the university should create an Energy Sustainability Fund. The Energy Sustainability Fund would allow facilities and building managers to take out loans to cover the initial investment of energy efficiency upgrades that could demonstrate significant potential energy savings.

Analysis of energy consumption shows that laboratory electricity use can generally be broken into 3 main categories, HVAC (66%), plug-in load (23%) and lighting (11%) (Figure 5)(Weale, 2005). Investments in newer and higher efficient technologies in these areas can make significant impact toward cutting total electricity use by labs.

- HVAC upgrades include the installation of higher efficiency units and systems such as variable air volume (VAV) systems. Such systems allow laboratory users to increase or decrease the amount of air going to their individual labs. This is opposed to the constant air volume units that have the capability to supply only one constant volume of air from the HVAC unit. Possibly the largest potential saving from VAV systems is through their ability to control the air changes in the lab space. Coupled with occupancy sensors and chemical sensors, VAV could allow air change rates to be scaled up or down depending on occupancy and the presence of potentially toxic chemicals. VAV systems with occupancy and chemical sensors have been shown to reduce laboratory energy consumption by over 50% (University of California Irvine, 2013).
- Lighting upgrades include the installation of new high efficiency lights or increased automation. Such upgrades can include the installation of LED lights, task lighting, occupancy sensors, daylight sensors and light timers.
- Equipment plug-in loads can be significantly decreased through the purchase of higher efficiency equipment. Often, laboratory equipment such as refrigerators or centrifuges are left on for prolonged periods of time due to research demands. Due to the extensive use of laboratory equipment, the installation of more efficient equipment would lead to significant energy savings.

The primary requirement for being eligible to take out a loan from the Energy Sustainability Fund is that the project manager must be able to demonstrate significant energy savings from the project. Energy Sustainability Fund projects will not be limited to the three areas mentioned above, rather they will be evaluated on the payback period from the resulting energy savings. If a proposed project can be demonstrated to have a payback period of less than 10 years, then it would be eligible for an Energy Sustainability Fund loan. To receive a loan, building and laboratory managers will be required to submit an application for the proposed project. Applications will be reviewed and selected by a designated group of individuals within the universities utility services on the basis of the payback period and the estimated energy savings. These individuals are compensated through the payback of the Energy Sustainability Fund. This process will give priority to projects that have the greatest impacts on energy efficiency across the campus.

Once a Sustainability Fund loan is given, it will be paid back through the monetary savings resulting from reduced energy consumption. As mentioned above, through the monetary incentive program that the university has implemented, two thirds of the money saved on electricity bills through voluntary, externally funded improvements will go back to the building and lab users. However, if savings are made through an upgrade from an Energy Sustainability Fund, the savings seen from that specific upgrade will be paid to the Energy Sustainability Fund to pay back the loan (Figure 2, A). Once the loan is paid back in full, the two-thirds monetary incentives from the upgrade savings will return to being paid back to the users. With this payment method, the university is paid back on their loans and building and laboratory managers are able to receive monetary benefits of the upgrades. This provides incentives to both parties to pursue these loans. To achieve the split payment of energy savings, each project must be accompanied with monitoring installations to track the savings associated with the specific upgrade. It is important to note that the university's F&A costs will not decrease because the money saved will directly pay the departments that save energy as well as payback the sustainability fund.

A concern with the creation of an Energy Sustainability Fund is the procurement of the initial funds. Initial seed money needed to create the fund can come from a variety of sources. First, it is possible for money to come from the university itself. Both private and public universities can view the establishment of this fund as an investment in the future of the campus and thus a worthy cause to allocate funds toward. Second, a university can reach out to private donors looking for external donations to cover the initial investment. Finally, the last option is to generate money through raising student fees. If, for example, student fees were to be increased by $2 a term to support the creation of the fund, this would provide a strong financial base for giving out loans.

Once a base of money for the fund has been established, the university would be able to sustain the fund from the money saved through energy efficient behavior and upgrades. Through the incentive program mentioned above, 1/3 of monetary energy savings are transferred to the Energy Sustainability Fund. The savings accrued over time would sustain the fund and allow more loans to be made. Take for example a university with an energy bill that is $1 million per month. Assuming that university is able to achieve a 10 percent cut in consumption would mean

a $100,000 saving per month in electricity and approximately $33,000 of that is going into the account monthly. This would mean that over the course of one year, with a 10% reduction in electricity consumption, the Energy Sustainability Fund account would be able to accrue $400,000 that would be able to be loaned out to upgrade projects. Under this structure, the university will see a return on their investment for energy efficiency upgrades, and the more energy savings realized, the more money will be placed back into the fund. Furthermore, because of this income, any increase in student fees would only have to be temporary to establish a strong funding base. If the university increase fees by $2 per term, for example, and diffuses that over a 10 year period (assuming that the school has 20,000 students), after 10 years the fund would have a $1.2 million base. This is a significant amount of money for the Energy Sustainability Fund to build off of for providing loans.

The Energy Sustainability Fund will also be used to cover the necessary expenses of the university's energy efficiency efforts. These costs include wages for additional energy managers and technicians, installation of necessary monitoring and any miscellaneous administrative costs associated with the effort to reduce energy consumption. The income from the ⅓ of the monetary energy savings will serve as the necessary funding to cover these expenses. After the costs have been paid all leftover funds are available for loans to efficiency upgrades. Furthermore, whatever is not spent on covering administrative costs will serve to grow the resources of the Fund to allow for larger and more frequent loans as well as expansion of the energy efficiency program efforts. By providing the incentive and ability to pursue large efficiency upgrades as well as providing funding for campus wide efficiency efforts, the Energy Sustainability Fund greatly expands a university's ability to reduce its energy consumption.

Education and Outreach:

Education and outreach is an important strategy to influence more energy efficiency behaviors in university laboratories. Along with increased access to information, a campus organization (comprised of volunteer and/or paid interns) will be created to assist with the increased monitoring systems mentioned above. This Energy Sustainability and Outreach Group, comprised of faculty, staff and student volunteers/interns will: 1) help install energy monitoring technology; 2) conduct sustainability assessments of labs (starting with the most energy intensive labs) to advise the lab managers and researchers where the most practical energy efficient upgrades should be made; 3) assist in teaching researchers and lab managers how to use the Labs21 app in order to provide the most comprehensive source of information on sustainable lab occupancy.

Conclusion:

Federal grant requirements for energy monitoring and the Labs21 application will provide a strong framework to implement energy efficiency initiatives at universities across the nation. This will lead to increased energy efficiency, monetary savings, carbon dioxide emission reductions and laboratory equipment efficiency data, benefiting all parties involved. Federal grant agencies can eventually save money through reduced F&A costs required to carry out the research. There is an incentive for the university to upgrade buildings and maintain more efficient technology in order to reduce expenditures on utility bills and potentially attract more researchers and students. Building managers can receive money to invest in energy efficiency improvements with little to no investment of that department's own money. Finally, minimal

time is taken away from research since researchers have to put forth little effort in terms of requesting energy equipment and infrastructure upgrades. Those duties fall onto the building and university facilities managers. Researchers and departments will also be able to utilize the money they receive from energy savings to invest in research, building improvements or other expenses. Ultimately**,** the establishment of the Energy Sustainability Fund provides the incentive and ability for universities to phase out aging or inefficient infrastructure and equipment. With the ultimate goal of utilizing only the most efficient technology, universities will be able to make significant long term reductions in the amount of energy they consume. Overall, the proposed solutions create a framework that facilitates cooperation between the federal agencies and universities. This framework allows these to separate entities to work closer together and align energy efficiency goals in order to capture the environmental and financial benefits of energy efficiency.

Appendix:

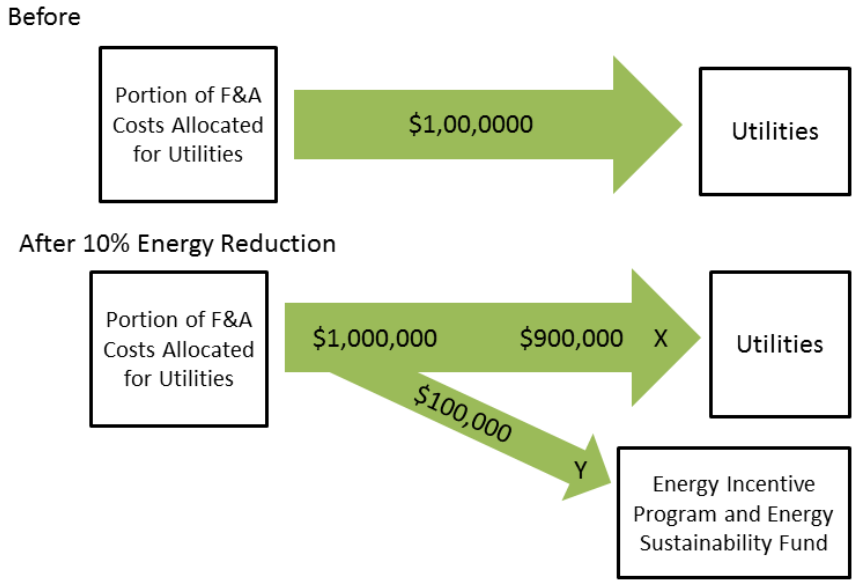

Figure 1. Demonstrates where the portion of F&A costs are allocated if energy is reduced by 10%. $900,000 will still go toward paying the utilities bill, but $100,000 will go toward funding the incentive program and Energy Sustainability Fund.

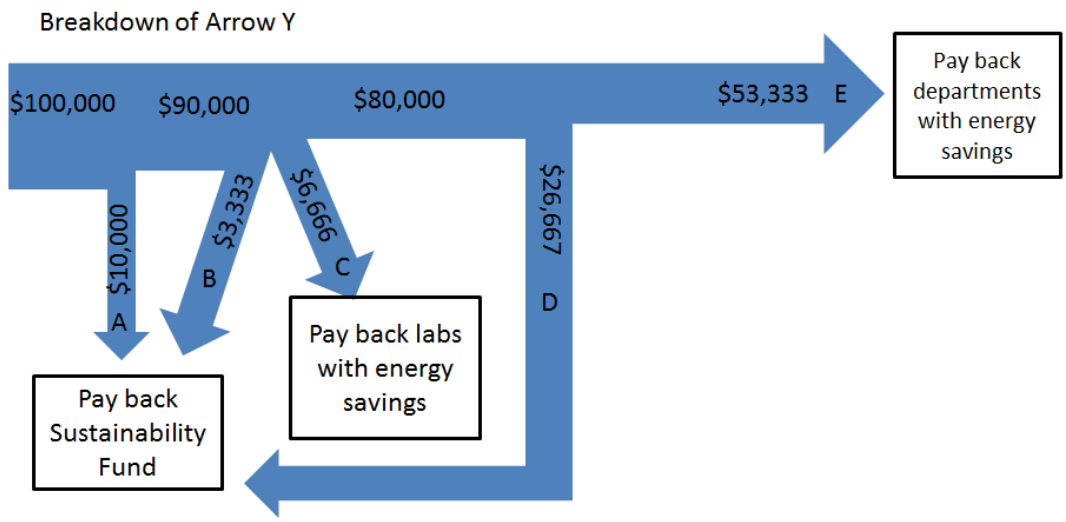

Figure 2. Demonstrates how funds are allocated to the incentive program and the Energy Sustainability Fund. Incoming money is used to pay back loans taken out for infrastructure and equipment upgrades (Arrow A). Individual labs also receive ⅔ of the money they save from increased energy efficiency (Arrow B) and ⅓ of the money goes back into the fund (Arrow C). Buildings or departments can also receive ⅔ of their energy savings (Arrow E) and ⅓ of the money goes back into the fund (Arrow D).

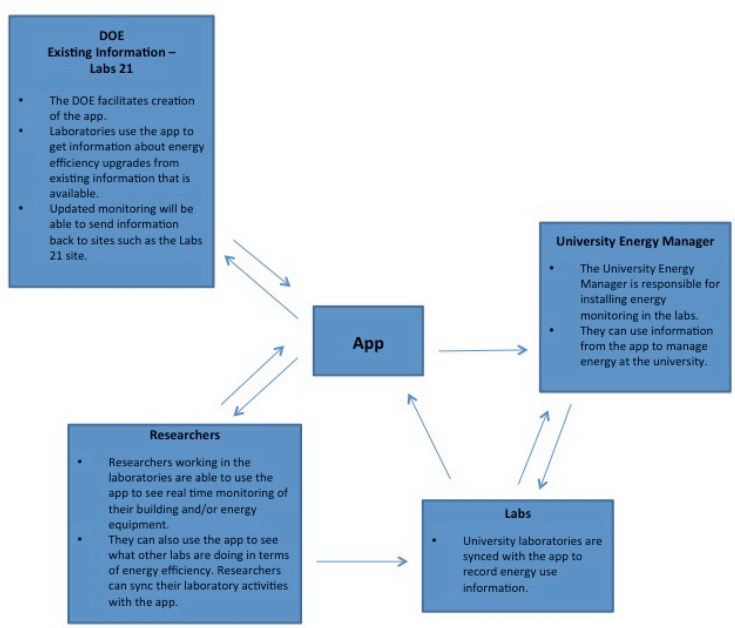

Figure 3: Diagram showing how the app links all the major parties involved in university laboratory energy efficiency.

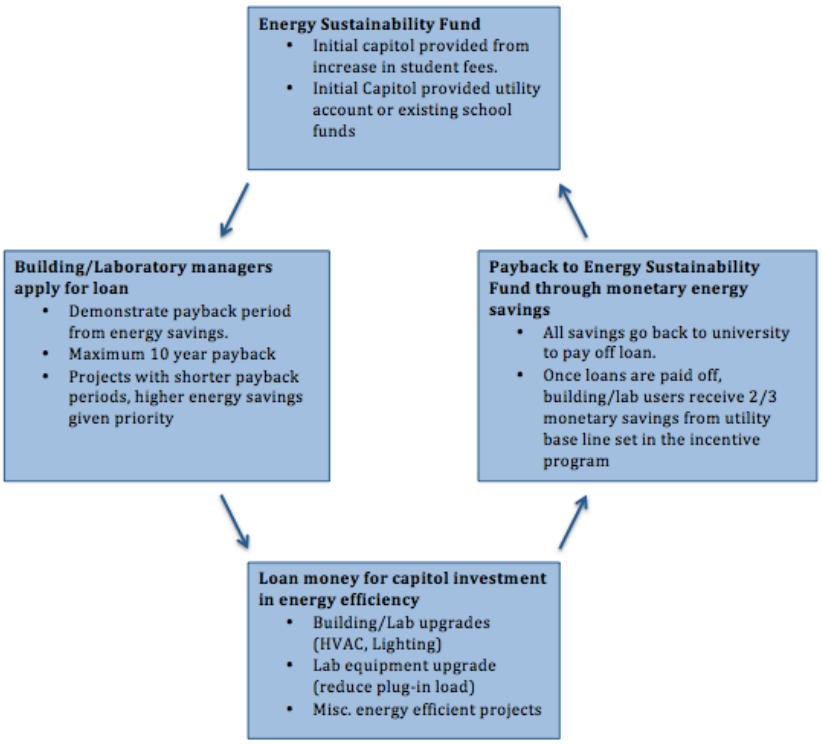

Figure 4. Flow diagram of the Energy Sustainability fund. Initial loans are made from the fund to invest in energy efficiency upgrades in lab buildings across the campus. Loans are paid back through the energy savings realized from efficiency upgrades. Once loans are paid back, building/lab users will receive ⅔ of the monetary savings off their baseline energy usage, the other ⅓ will continue to be paid into the Energy Sustainability Fund.

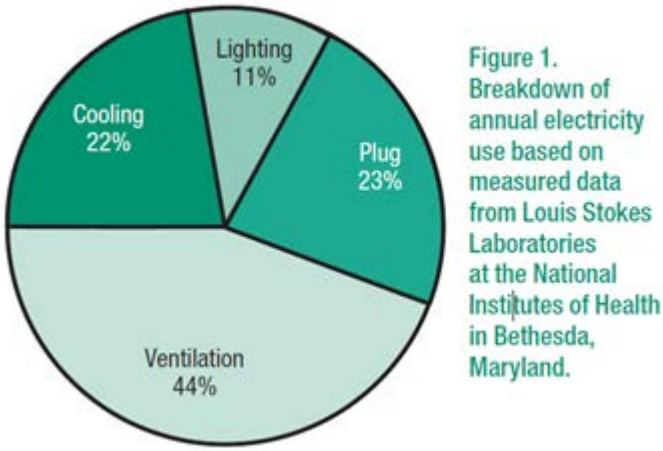

Figure 5. Electricity usage in laboratories can be broken into 4 main categories, lighting, plug cooling and ventilation. Cooling and ventilation can be further compiled into one section for HVAC requirements. These main categories comprise the areas of greatest potential energy

savings through efficiency upgrades that require capital investment. *Graphic courtesy of Louis Stokes Laboratories at the National Institutes of Health (Weale, 2005).*

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