STUDENT SUSTAINABILITY COMMITTEE

Funding Application – Step II

Funding Criteria

A. General Rules

1. Students, faculty, and staff are encouraged to submit requests for funding. Student-led projects require a faculty or staff sponsor in order to have funds awarded.
2. Funding can only go to university-affiliated projects from students, faculty, staff, and departments.
3. All SSC projects must make a substantial impact on students. This may be a direct impact or an impact through education and engagement. All SSC funding is 100% from student green fees, so the projects funded by the students must benefit them.
4. SSC encourages innovation and new technologies – creative projects are encouraged to apply.
5. Unless a type of expense is specifically listed below as having restrictions, SSC can generally fund it. The items referenced below should not be taken as comprehensive list.

B. Things SSC Can Fund, On A Case-By-Case Basis

1. SSC can fund feasibility studies and design work; however, it must work toward ultimately addressing a sustainability need on campus.
2. SSC can fund staff positions that are related to improving campus sustainability. Strong preference will be given to proposals receiving matching funding from departments and/or plans for maintaining continuity of the position after the end of the initial grant.
3. SSC can fund outreach events with a central theme of sustainability, provided their primary audience is the general campus community.
4. SSC discourages funding requests for food and prizes but will consider proposals on a case by case basis that prove significant reasoning.
5. SSC can fund repairs and improvements to existing building systems as long as it works toward the goal of improving campus sustainability; however, a preference is shown to projects utilizing new or innovative ideas.
6. SSC can provide departments with loans for projects with a distinct payback on a case by case base. Loans will require a separate memorandum of understanding between SSC and departmental leadership pledging to repay the award in full and detailing the payback plan.

C. Things SSC Will Not Fund:

1. SSC will not fund projects with a primary end goal of generating revenue for non-University entities.
2. SSC will not fund personal lodging, food, beverage, and other travel expenses.
3. SSC will not fund any travel expenses.
4. SSC will not fund tuition or other forms of personal financial assistance for students beyond standard student employee wages.

Your Step 2 funding application should include this application, the supplemental budget form, and any letters of support.

Please submit this completed application and any relevant supporting documentation to Sustainability-Committee@Illinois.edu. The Working Group Chairs will be in contact with you regarding any questions about the application. If you have any questions about the application process, please contact the Student Sustainability Committee at sustainability-committee@illinois.edu.

General & Contact Information

Project Name: Intelligent Mobile Sensing Unit for Building Energy Efficiency
Total Amount Requested from SSC: $35,198.52

Project Topic Areas: ☐ Land & Water ☐ Education ☒ Energy
☐ Transportation ☐ Food & Waste

Applicant Name: Nidia Bucarelli
Campus Affiliation (Unit/Department or RSO/Organization): Civil and Environmental Engineering Department
Email Address: nidiaib2@illinois.edu

Check one:
☒ This project is solely my own **OR**
☐ This project is proposed on behalf of (name of student org., campus dept., etc.):

Project Team Members

Name	Department	Email
Nidia Bucarelli	Civil and Environmental Engineering	nidiaib2@illinois.edu
Nora El-Gohary	Civil and Environmental Engineering	gohary@illinois.edu
Morgan White	Facilities and Services	mbwhite@illinois.edu
Name	Department/Organization	Email Address

Student-Led Projects (Mandatory):

Name of Faculty or Staff Project Advisor: Nora El-Gohary

Advisor's Email Address: gohary@illinois.edu

Financial Contact *(Must be a full-time University of Illinois staff member)*

Contact Name: Heidi Thiele

Unit/Department: Civil & Environmental Engineering

Email Address: hlgreen2@illinois.edu

Project Information

Please review the proposal materials and online content carefully. It is <u>highly recommended</u> you visit a working group meeting sometime during the proposal submission process.

Please provide a brief background of the project, its goals, and the desired outcomes:
You may copy and paste your Step 1 application answer if nothing has changed.

Most of the current initiatives for energy savings are not adaptive and rely on (1) models that are not generalizable, which use limited data in terms of size and variability that are collected from fixed/rigid sensors installed in limited locations, and/or (2) pre-defined standards, schedules, or limited occupant feedback, which prevents energy-related strategies to be coupled with occupant thermal comfort preferences. To tackle these limitations, the proposed project would bridge the gaps between building energy efficiency and (1) the initiatives that cannot be fully or efficiently implemented because of infrastructure requirements, (2) occupant thermal comfort feedback in the system feedback loop, and (3) lack of generalizability or external validity.

The goal of this project is to develop an intelligent system that (1) can autonomously navigate in Campus building spaces, **limited to open spaces (e.g., open spaces in student offices and other lounge/student areas) and excluding classrooms and other types of offices (e.g., faculty and staff offices). <u>The experiments for this project will be limited to the following space: Room 2017, Civil Engineering Hydrosystems Laboratory Building</u>**; (2) can collect data on the indoor environmental conditions (e.g., temperature, humidity, lighting levels) using multimodal sensors, and (3) recommend indoor environmental settings for energy savings and increased occupant comfort. The mobile unit will be integrated with the following components:

Physical Components:
1.   Sensors (mounted on the robotic unit) to read indoor physical parameters (temperature, humidity, lighting levels, CO_2, etc.).
2.   Charging station to periodically charge the unit.
3.   CPU to command and manage the system.

System Components:
1.   Autonomous navigation. It includes mapping, collision avoidance and adaptive navigation (e.g., learn the sensing locations for accurate energy prediction).
2.   Data collection and communication. It includes the collection of indoor physical parameters (using the mounted sensors) and connection to a database.
3.   Optimization. It includes algorithms for (1) predicting the building energy consumption (e.g., based on indoor conditions, weather conditions, time of the day), (2) predicting the occupant thermal comfort states (e.g., based on occupant data and indoor conditions), and (3) recommending indoor condition settings that balance energy savings and occupant thermal comfort.

For enhanced safety and to help prevent tripping hazards, the unit will be integrated with (a) a vertical stick with a height equivalent to the eye-level height and (b) a sound system that "beeps" in proximity to occupants. In addition, in collaboration with F&S, we will ensure that we comply with all applicable safety standards, which are regulated by F&S. An example of the expected unit, the TurtleBot 4 (TB4), is shown in the figure below. The TB4 will serve as a mule to carry the physical components listed above. The following link can be used to see an example of the mobile unit navigating in a building during a set-up process: https://www.youtube.com/watch?v=5D_pnLONa_A&t=25s.

Where will the project be located? Are special permissions required for this project site?
If special permission is required for this location, please explain and submit any relevant letters of support with the application.
To test and validate the proposed intelligent system, a graduate area (Room 2017) on the second floor of the **Civil Engineering Hydrosystems Laboratory Building** will be used as a testbed. A total of 54 students occupies the area. The Civil and Environmental Engineering Department (including faculty, staff, and students) is very supportive and enthusiastic about this project and its potential to support the students, and no special permission is required. Once this proposal is approved, the team will schedule talks/meetings with the subjects to (1) explain the scope of the research and plan for their participation during the test phase. All necessary IRB approvals will be obtained.

After our experiments, the unit could be deployed on other Campus facilities (e.g., in open spaces). It is expected to have self-learning capabilities to unknown settings.

Other than the project team, who will have a stake in the project? Please list other individuals, groups, or departments affiliated directly or indirectly by the project. This includes any entity providing funding (immediate, future, ongoing, matching, in-kind, etc.) and any entities that benefit from this project.
Please attach letters of commitment or support at the end of the application.
•   Facilities and Services
•   Institute for Sustainability, Energy, and Environment (iSEE)

How will this project involve and/or benefit students?
This includes both direct and indirect impact.

- Most of the UIUC current initiatives for energy savings are not adaptive and rely on (1) models that are not generalizable, which use limited data in terms of size and variability that are collected from fixed/rigid sensors installed in limited locations, and/or (2) pre-defined standards, schedules, or limited occupant feedback, which prevents energy-related strategies to be coupled with individualized occupant preferences. For instance, interviews of 34 subjects at Newmark showed that 62% of the participants were not satisfied with the indoor conditions while working indoors. The biggest pain points with the indoor conditions reported by 79% of the participants included being too cold in winter and/or too hot

in summer, with 48% of the participants further indicating a consequent decrease in their productivity. These results suggest that often we encounter simultaneous energy waste and occupant dissatisfaction on Campus (e.g., when a space is over cooled). The proposed intelligent system would contribute to tackling this problem. The team will test and validate a mobile system that is not rigid and could be adapted to unknown buildings on-campus, used to monitor indoor environmental conditions, collect effortless feedback from building occupants, optimize building energy consumption based on occupant thermal comfort preferences, and recommend ways to reduce energy consumption. During the experiment/test phase, 54 students from the Civil Engineering Hydrosystems Laboratory Building will be the subjects. They will be active agents of the testbed and will provide comfort feedback (through cues, indirectly) to the mobile unit. The outcome of these experiments would pave the way to use mobile sensing units aiming to reduce building energy consumption, improve occupant thermal comfort, and ultimately enhance health and work productivity on Campus. It could impact more than 56,000 students and nearly 11,000 faculty and staff (based on Fall 2021 statistics)

- The mobile unit could support student research aiming to test energy-saving strategies without the upfront investments of traditional infrastructures (e.g., fixed/rigid network of sensors), which are also limited by coverage and scalability.
- The mobile unit could also support hands-on teaching opportunities for students (e.g., in course demonstrations or student course projects) who could use the unit to test/demonstrate the impact of different energy-saving strategies.

How will you bring awareness and publicize the project on campus? In addition to SSC, where will information about this project be reported?
The research and educational outcomes will be disseminated through:
- F&S website
- News release
- iCAP portal
- Sticker on the robot noting the SSC's funding support
- Journal Publications
- Conference publications and presentations

Financial Information

In addition to the below questions, please submit the supplemental budget spreadsheet available on the Student Sustainability Committee website. Submission of both documents by the submission deadline is required for consideration of your project.

Have you applied for funding from SSC before? If so, for what project?
Yes, the current project is an extended scope of the "Submetering for Supporting Energy Savings and Sustainability" project, currently funded by SSC.

If this project is implemented, will you require any ongoing funding required? What is the strategy for supporting the project in order to cover replacement, operation, or renewal costs?
Please note that SSC provides funding on a case by case basis annually and should not be considered as an ongoing source of funding.
To expand the scope and achieve an impact at a bigger scale on Campus, the team is planning to submit a funding proposal to the NSF.

Please include any other obtained sources of funding. Have you applied for funding elsewhere?
Please attach any relevant letters of support as needed in a separate document.

Yes.
1. iSEE funded $30,000 for preliminary studies as part of the Campus as a living lab program in the past (2019-2020).
2. F&S funded $25,600 for the OAR submetering project for electricity usage (Spring 2021) and $18,500 for Nidia's partial time (Summer 2021-Fall 2021).

Environmental, Economic, and Awareness Impacts

How will the project improve environmental sustainability at the Urbana-Champaign campus? If applicable, how does this project fit within any of the [Illinois Climate Action Plan](#) (iCAP) goals?

The proposed project will allow the Campus to gather indoor physical parameter data –with minimal effort and investment– that allows making more informed decisions about effective energy-use strategies and to verify and benchmarks energy-savings initiatives. This project will provide:

- o Accurate indoor condition monitoring
- o Ability to identify and eliminate wasted energy.
- o Ability to test energy-savings strategies and find opportunities for improvement.

The project will contribute to several Campus initiatives and programs that aim to increase environmental stewardship at UIUC, including (1) the iSEE's campus as a living lab program, (2) the Illinois climate action plan (iCAP), and (3) the "Smart, Healthy Communities" initiative.

The mobile unit could support energy-savings initiatives/technologies that will contribute with the iCAP objective 2.2. which aims to reduce Energy Use Intensity (EUI) of university facilities and the total annual energy consumption of each college-level unit by at least 20% from an FY15 baseline by FY35. For instance, this project could pave the way to use mobile units with sensing capabilities to monitor indoor conditions, thermal comfort feedback, and recommend ways to reduce building energy consumption with minimum deployment efforts on Campus facilities. Savings potential from strategies that consider occupant feedback has been estimated to be in the range of 4-32%, depending on building characteristics and climate.

How will you monitor and evaluate the project's progress and environmental outcomes? What short-term and long-term environmental impacts do you expect?
Some examples include carbon emissions, water conservation, green behavior, and reduced landfill waste.
Short-term impact:
- The unit will help to reduce building energy consumption, improve occupant thermal comfort, and enhance productivity on Campus.
Long-term impact:
- A smart building on Campus that is capable to reduce building energy consumption. This will help reducing energy waste and carbon emissions on Campus.

What are your specific outreach goals? How will this project inspire change at UIUC?

We will create energy awareness through a Webinar to encourage the UIUC community to reduce building energy consumption and change their energy-behavior. Webinars will offer information about energy consumption and waste on Campus, existing energy-savings strategies, energy footprint of occupant behavior and at the Campus level (e.g., CO2 emissions), and opportunities for energy savings.

If applicable, how does this project impact environmental injustice or social injustice?

n/a