

New Brunswick Strategic Planning Proposal

Proposal Title: Campus as Living Lab

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Primary Strategic Priority/Foundational Element/Integrating Theme Addressed (Select one)

- Envision Tomorrow's University
- Build Faculty Excellence
- Transform the Student Experience
- Enhance Our Public Prominence
- Strong Core of Sciences and Humanities
- Inclusive, Diverse, and Cohesive Culture
- Effective and Efficient Infrastructure and Staff
- Financial Resources Sufficient to Fund Our Aspirations
- Robust Shared Governance, Academic Freedom, and Effective Communication
- Cultures, Diversity, and Inequality—Local and Global
- Improving the Health and Wellness of Individuals and Populations
- Creating a Sustainable World through Innovation, Engineering, and Technology
- Educating Involved Citizens and Effective Leaders for a Dynamic World
- Creative Expression and the Human Experience
- Measuring Progress and Defining Success

Proposal Abstract

We propose to turn portions of the New Brunswick campuses into living laboratories that allow Rutgers faculty, staff, and students to engage in learning and research on built-environment topics. Ongoing and substantial investments in physical plant on the New Brunswick campuses make it possible to incorporate sensors and data retrieval equipment into selected buildings at a low incremental cost. These systems would enable the collection of big data on both behavioral and engineering topics. Current courses that could use these data for instruction include Green Buildings (Bloustein, Andrews) and Building Information Modeling (Engineering, Gong), among others. Currently, Rutgers researchers must acquire such data at other sites but could more cost-effectively conduct such research here. Working with the Rutgers facilities staff, we envision that some elements of these systems can be incorporated within planned building designs and renovations at little incremental cost because they are standard components of building management systems. Other items and most ongoing research activities will be paid for with external grant funding. We request support to (1) develop a protocol specifying how researchers and instructors should engage with Rutgers Facilities staff; (2) install a pilot system in one building; (3) incorporate the pilot data collection effort into one course; and (4) conduct one proof-of-concept research project.

Full Proposal Description

Development of “living laboratories” has been increasing in popularity at universities across the nation. A living laboratory is a flexible space that allows for easy interchangeability of technologies and also occupants to conduct research on a particular topic of interest or even multiple studies of evolving scope. At university campuses, these living labs can provide for a significant learning experience as well as a test-bed for new technologies and innovations. Living labs typically provide for opportunities for cross-disciplinary learning and research, involving multiple departments and schools within a university. They afford professors the ability to integrate experiential learning into the curriculum and provide students with hands-on, project- based experience to supplement the traditional classroom environment. Living labs also present the university with a facility to engage the larger community as well as the internal population. Finally, such a lab can afford the university and its internal stakeholders to forge meaningful, symbiotic partnerships with industry.

Notable university-based living labs include the Robert L. Preger Intelligent Workplace – Carnegie Mellon University; Lotus Living Laboratory – Stanford University; Herrick Labs – Purdue University; and the Home Depot Smart Home – Duke University. Notable government and industry living labs include the Home Innovation Research Labs – National Association of Home Builders; and the Research Support Facility – National Renewable Energy Laboratory. These institutions have a “built-in” advantage in pursuing built-environment research.

The proposal for creation of a living laboratory at Rutgers University to examine high- performing building technology potentially takes many forms, may be housed in multiple buildings and may encompass various research outcomes. For the purposes of this proposal, three approaches were selected as being the most realistic near-term opportunities to create living lab facilities at the University. These approaches would involve space that is highly instrumented to collect data on building performance and occupant behavior. These approaches would rely heavily on industry and University partnerships for construction and operation. The approaches can be pursued simultaneously.

Dedicated new facility: It could be a dedicated on-campus living laboratory. Its mission would be to serve as a test bed in building technologies by allowing interchangeability of building systems for



use as a learning tool. The lab would serve as a collaborative space for students to work on studio or other design projects and also provide a dynamic space to hold interdisciplinary courses on green building and sustainability. The lab would additionally offer an opportunity for the study of occupant perceptions and response to indoor environmental conditions in buildings and the usability of various building systems. One possibility is to reconstruct the 2011 Rutgers/NJIT ENJOY Solar Decathlon home as a 1000 square foot on-campus

living laboratory. The proposed name for the building is the Rutgers University <Major Sponsor Name> Green Building Lab. We estimate that the total cost for reconstructing the Solar Decathlon house, fitting it out, and operating it for one year to \$500k. Other new facilities would have comparable costs, depending on size and scope.

Equipping a new facility: As new buildings are built, enhanced building management systems (BMS) could be specified that monitor and record indoor and outdoor environmental conditions, systems status, and selected aspects of occupant behavior such a building occupancy. Estimated

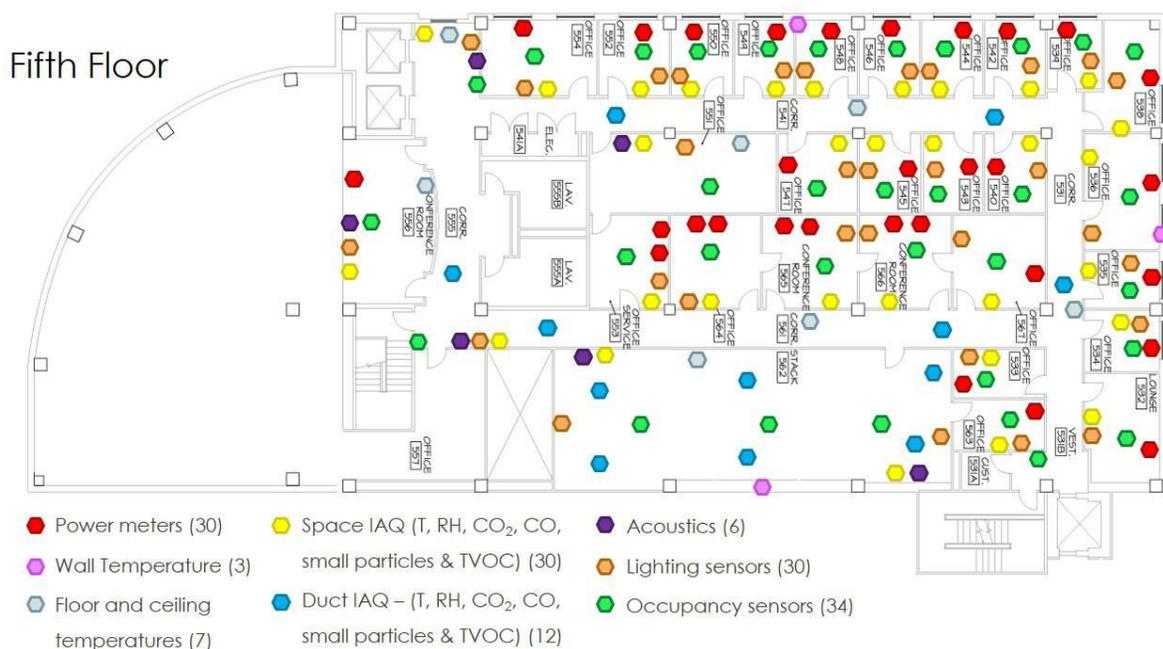
costs would be lower than those reported below for the retrofit case, that is, less than \$100k in hard costs.

Retrofitting an existing building: The third approach we propose is the retrofit of an existing campus building, or portion of a building, as a living laboratory. The proposed name for the lab space is the Rutgers University <Major Sponsor Name> Lab for Workplace Innovation. Its mission would be to study occupant perceptions and response to indoor environmental conditions, specifically in commercial buildings. The lab also would be set up so as to evaluate how occupants rate the usability of various building systems in the context of the workplace. In discussions with Facilities staff, we have identified two candidate buildings: the Rutgers Visitor Center (Busch Campus) and the Bloustein School's Civic Square Building (College Avenue Campus). The Rutgers Visitor Center has the advantage of being a relatively simple building whose BMS could be easily upgraded, although it has the disadvantage of atypical usage patterns. The Bloustein School is in a more complex, older building but it contains typical office and instructional uses. For the purpose of this proposal, we will illustrate the possibilities using the Bloustein School.

For construction of the Workplace Innovation Lab, the instrumentation installation process would begin at the Edward J. Bloustein School in the Civic Square Building, which also houses the Rutgers Center for Green Building, a leader in occupant behavior research. The school occupies one half of the building from the ground floor/lobby space up to the fifth floor, totaling approximately 50,000 square feet. There are plans in place to redesign the fifth floor of the building on the Bloustein School side to bring daylight into the floor through skylights and glass walls on the interior offices. There have been discussions with the School's administration to incorporate instrumentation and monitoring of occupant behavior and the indoor environment as part of these renovations. The monitoring scheme for the fifth floor of the Bloustein School also models that of Building 101 at the EEB Hub as a guiding example and is displayed below.

Following the fifth floor renovations, the incorporation of sensors and other building monitoring equipment would continue and be built into the Bloustein School's capital plan. The instrumentation would be installed in all offices, classrooms, laboratories and common areas of the building. Eventually, the monitored space could expand to the rest of the Civic Square Building, currently occupied by the Mason Gross School of the Arts, and then to other buildings on the Rutgers-New Brunswick Campus. The goal would be to build smart building technology to all campus buildings to allow for monitoring and control of the entire campus as an integrated system.

This approach is proposed to engage in a dual path strategy for establishment of a Workplace Innovation Lab. The second path, which can be pursued in parallel to instrumentation of the building, would be to designate a pair of offices on the fifth floor (or elsewhere) as lab space. This would allow for the opportunity to install flexible "plug and play" mechanical systems in one office for the purpose of independently controlling the second office. The second office could be occupied by a member of the faculty or staff, and the indoor environmental conditions therein tested and monitored. The occupant's perceptions and response to the environment could be observed. Innovative technology, lighting, envelope features and workplace set-up would all be subject to



There are many opportunities for study in an existing campus building to understand occupant behavior and measure comfort. Physical modifications can be made to the building envelope and interior in order to experiment with various options for occupants to adjust their indoor environment and provide options for better thermal comfort. The Civic Square Building does not currently have operable windows, which prohibits natural ventilation from playing a role in thermal comfort. Other opportunities to introduce daylight or adjusting the façade of the building with insulation and shading could present further study. The installation of on-site renewable, should this prove feasible, would allow for study of the building as a Power Plant.

Much like the dedicated Green Building Lab approach, experimentation with various control schemes and platforms, as well as different mechanical systems, would be conducted in the Lab for Workplace Innovation. Also in the interior of the building, workplace environment modifications could be made to study productivity and occupant satisfaction, such as the installation of modular, open floor plan workspaces for collaboration and flexibility. There is significant opportunity in the building to allow for increased user-controlled environments. Alternate methods of lighting such as the installation of more task lighting or IP addressable ballasts are two such examples.

Since instrumentation of the fifth floor of the Civic Square Building on the Bloustein School side is expected to take place in conjunction with planned renovations of the space, the marginal cost to install instrumentation and monitoring equipment should be fairly minor, estimated at this time to be approximately \$98,000. See Appendix A for a more detailed breakdown of the budget.

Instrumentation and Monitoring Equipment (Material and Labor)

Installed cost of instrumentation	\$61,394
Installed cost of Building Management System	\$22,668
Power meters (wireless)	\$7,080

Light sensors	\$6,000
TOTAL INSTRUMENTATION & MONITORING	\$97,142

For its estimated annual operating budget, the Innovative Workplace Lab is expected to incur costs of approximately \$141,000 per year.

Financial Sustainability Strategy

The cornerstone of the funding strategy to either implement the Green Building Lab or the Innovative Workplace Lab is the formation of a consortium to support the Labs' research efforts, both with expertise (technical knowledge) and monetarily. The work of pulling together these consortia is jump-started by leveraging existing supporters from the Solar Decathlon experience and from the existing and past funding rosters of the Rutgers Center for Green Building and its university-based partners. Thus, the consortium ultimately will comprise of key stakeholders at Rutgers University, major and minor industry partners, governmental agencies and nonprofit organizations. A well-balanced consortium facilitates interdisciplinary academic programming focused on sustainable building practices and operation, indoor environmental conditions, and ultimately people-technology studies.

A guiding example of this kind of coalition is found at the Intelligent Workplace living laboratory at Carnegie Mellon University – the Advanced Building Systems Integration Consortium. The Consortium consists of corporate members such as Bank of America, Johnson Controls, Inc., LG-Honeywell Co., Ltd. Siemens Energy & Automation, Inc., among others. Federal agency members include the National Science Foundation, U.S. Department of Energy and U.S. Environmental Protection Agency.

The strategy for securing funding for the Innovative Workplace Lab is similar, although it may rely more so on the pursuit of federal research grants, as well as foundation grants, to support its operation. The following federal grant programs, in particular, have been identified as plausible funders.

US DoE Office of Energy Efficiency and Renewable Energy

- Building Technologies Office Prioritization Tool
- Energy-Efficient Building Technologies

National Institute of Standards and Technology (NIST)

- Precision Measurement Grants
- Technology Innovation Program

National Science Foundation (NSF)

- Many grants available for intelligent buildings, occupant behavior and building systems

Moreover, both the Green Building and Innovative Workplace Labs will provide Rutgers University with excellent venues to partner with local community groups for education, outreach and other public events in which to strengthen the University's relationship with the New Brunswick-area community and the State of New Jersey. An exceptional event to showcase the partnership forged through the creation of the Labs is the annual Rutgers Day.

Alignment with the Strategic Plan

Although we checked the single box “Creating a Sustainable World through Innovation, Engineering, and Technology,” we believe that this living lab proposal addresses several additional themes in the university’s strategic plan. These include: “Envision Tomorrow’s University” (campus is no longer a passive object); “Transform the Student Experience” (student can become engaged in studying their local environment); “Enhance Our Public Prominence” (living labs have done that for Carnegie Mellon, Stanford, Purdue & Duke); “Effective and Efficient Infrastructure and Staff” (better monitoring will help Facilities in both design and operations); and, especially important, “Improving the Health and Wellness of Individuals and Populations” (occupant comfort, health and productivity correlates with building conditions, a campus living lab also generates widely applicable insights).

People Involved to Date

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Jie Gong, Assistant Professor
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Mike Kornitas, Manager
Rutgers University Facilities/Committee for Sustainability

Proposed Measures to Mark Progress or Determine Success

Success should be measured as the value added in three dimensions: (1) as an instructional tool; (2) as a tool for attracting external research funding; and (3) as an aid to better facilities operations. Instructional value should be measured by the number of students using the living lab, and whether it beneficially affects their career trajectories 5 years out. Research value should be measured by \$\$ of external funding and peer reviewed publications tied to the living lab. Operational value should be measured by occupant complaints, service calls, and energy bills for the living lab compared to other campus facilities.