Paper ID APEN-MIT-2019_237
Applied Energy Symposium: MIT A+B
May 22-24, 2019 • Boston, USA

The Sustainable Campus Project: An ‘A + B’ Transformation in University of Campinas

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Abstract—This paper presents the Sustainable Campus project at UNICAMP - Brazil, started in January 2017. With a year in progress, the project introduces unexpected results and beyond the initial proposal. The organization structural change and the academic community support contribute to new advances in management, continuous improvement, multi professional participation and new public, private and social partnerships. Thus, the results shown here will serve as a guide for future projects and important points for sustainability development on university campus.

Keywords—energy sustainability, energy efficiency, green campus

I. Introduction

According to [1], the world needs simultaneous and complementary energy transformations in two directions, which are indicated as: (A) implementation of existing, sustainable and consolidated technologies, with production scale to reduce costs and expand access; and (B), as new sustainable technologies and models, which may even be part of the viability of (A).

In 2017, the University of Campinas - UNICAMP, started a public-private partnership project with the electricity utility company CPFL Brazil. Titled as Sustainable Campus Project - SCP, which aims to transform the University into a living laboratory for sustainability applications in campus and smart cities [2]. The SCP is transforming the campus in (A) and (B) direction in your infrastructure, organizational chain, researches, teachings and management [3].

Promoted and sponsored by UNICAMP's energy management technical chamber, the project was built with focus on the sustainable development goal number seven- SDG #7. Its choice was due to the importance of its results in other SDGs, as can be observed in the World Bank's State of Electricity Access Report [4], Fig. 1.

Therefore, this article shows the project structure (item II), its expected benefits (item III) and the short, medium and long term goals (item IV), as well as the results already achieved and the long learning process in two-year project, at the Conclusion (item V).

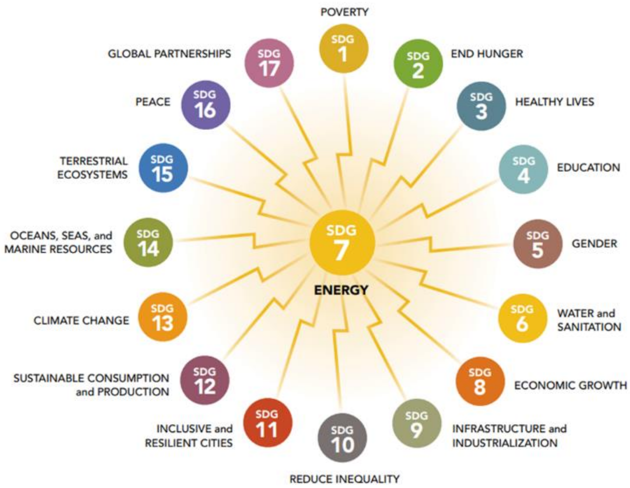

Fig. 1. SDG#7 according to World Bank in State of Electricity Access Report [4].

II. The Sustainable Campus Project

The Sustainable Campus Project (SCP) has 42 researchers, including professors and postdoctoral, doctoral, master and undergraduate students, as well as the participation of three startup companies to develop solutions in electricity measurement, IoT and electricity distribution systems analysis.

Thus, with an investment of approximately US$ 5 million dollars, SCP will develop several energy-sustainable applications and solutions in 48 months (since September 2017) for university campuses and smart cities.

The planned subprojects are (Fig. 2):

- Subproject 1: Power system operation center;
- Subproject 2: Photovoltaic generation;
- Subproject 3: Electric vehicle;
- Subproject 4: Retrofit for energy efficiency;
- Subproject 5: Energy Efficiency with IoT;
- Subproject 6: Education and knowledge sharing;
- Subproject 7: Building labeling;
- Subproject 8: Energy procurement.

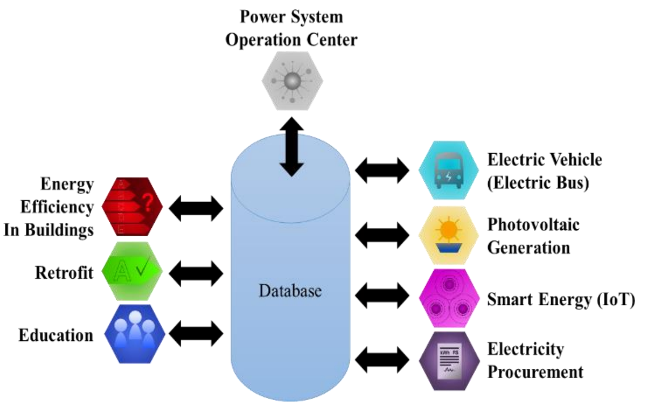

Fig. 2. – Sustainable Campus Project Structure

A. Power System Operation Center

The Operation Center is the heart of the entire project system and future applications of sustainable cities in the living lab. That is, it concentrates all data collection and visualization, metrics, information, decisions, research and routine analysis for all actions and operation of each subproject.

Initially, it will support studies and simulations for the university's internal power distribution system, with classic load flow analysis, short circuit calculation, stability tools, among others. At the same time it will indicate to the campus planning and maintenance team the distribution lines status, and the individual consumption of each transformer allocated within the campus, to assist in decision making.

Beyond the electrical system view, the operation center will have a campus mobility dashboard showing real-time bus position, waiting time at the pick-up/drop-off points and route optimization. It will also be able to view the positions and data collected by various IoT sensors installed inside the campus.

Therefore, the center is the actual applied application in the market, as (A), but with elements of (B), ensuring new methodologies implementation for energy efficiency and sustainability for smart cities.

B. Photovoltaic Generation

This subproject aims to implement (A) by installing 534 kWp in different university regions, roofs, carports and ground, with different technologies (B), in order to test its applications and efficiency, such as comparing standard polycrystalline silicon systems with double-glass systems.

In addition to the benefit of renewable energy generation, this subproject will ensure new equipment development for the national photovoltaic market, with low cost standard equipment, such as an IxV curve plotter and a national simulation software to predict and project photovoltaic generation.

C. Electric Vehicle

The campus has already been used for electric car testing in another R&D project. However, this subproject is implementing a state-of-the-art electric bus (BYD-model), which will be used as the university's internal transportation. Thus, its application (A) will ensure the use comparison of this technology with diesel motor vehicles.

However, new sensors and IoT technologies will be implemented inside the electric bus in order to optimize their use and evaluate passenger and driver comfort throughout its operation (B). In addition, technologies (A) will be implemented for the electric charge station, which will be zero carbon at the end of a year. That is, with the use of photovoltaic power generation, batteries and charging optimization, it will be possible to have a zero balance of utility power consumption to charge the vehicle (B), Fig. 3.

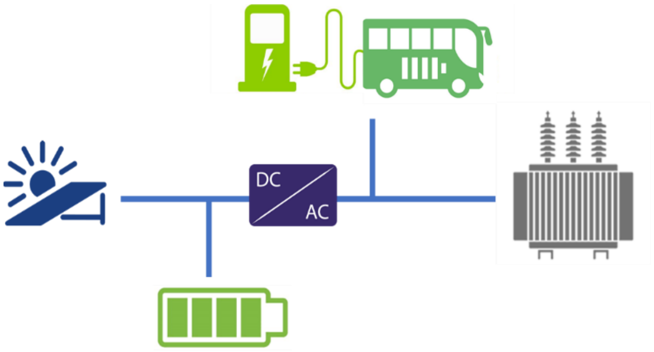

Fig. 3. Sustainabel electric bus charge station diagram.

D. Retrofit for Energy Efficiency

In addition to simply replacing obsolete electrical equipment with more efficient equipment, this project aims to expand university asset management for the efficient exchange of equipment labeled as energy efficient.

Its first implementation, through the exchange of equipment from the Faculty of Mechanical Engineering, with the replacement of 3,000 lamps and 43 environmental conditioning devices, this project allowed the replication of the method and analysis to other entities, being strongly supported by the institution's senior management. .

Thus, through the energy management technical chamber, the simple retrofit will become a broad program for purchasing, disposing and sizing electrical equipment at the university.

E. Energy Efficiency with IoT

Beyond the automation of environments through IoT technology usage (A), this subproject intends to deepen in human behavior (B), that is, through information and tips for indoor environments users such as classrooms, meeting, offices, etc., those users will determine the actions for their environmental comfort. Thus, with information on environmental benefits, such as lowering the concentration of CO2 indoors, ensuring the ideal working temperature, as well as the proper lighting to perform certain activities, they can observe in real time the energy consumption reduction that they are promoting.

This system is based on several types of IoT sensors, such as: CO2 concentration, temperature, humidity, luminosity, number of people inside the environment, among others; portable control and data hub modules, to collect all measured data and send it to the cloud; a web server system, with database and data analytics; and a mobile app as user interface, to show in real-time the environment dashboard and to collect the user's felling of environmental comfort, Fig. 4.

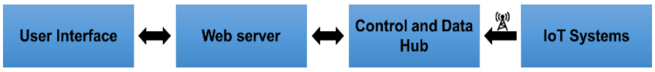

Fig. 4. IoT configuration for energy efficiency behaviour.

F. Education and Knowledge Sharing

Education and knowledge sharing are essential for the research to be perennial. That is, ensuring that actions replicate over the long term through users without the institution having to re-invest in similar projects. Therefore, this subproject is responsible for unifying all the others and building the acquired knowledge into something replicable and information, Fig. 5.

To this end, this subproject will proposes the implementation of extracurricular subjects in undergraduate and postgraduate courses, extension courses for internal and external community training, topics dissemination in lectures and congresses and, finally, a book publication with all results, difficulties, lessons learned and step by step project.

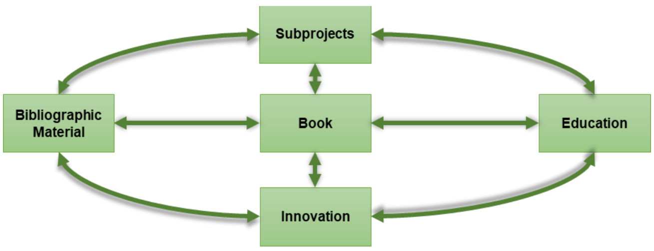

Fig. 5. Knowledge Management Structure

G. Building Labeling

Brazil has the Brazilian Labeling Program [5], under the coordination and responsibility of INMETRO (National Institute of Metrology, Quality and Technology). This program aims to label and classify equipment according to its efficiency. Within this program, there is another module responsible for the buildings labeling (A), according to its energy efficiency in the characteristics: envelope, lighting and environmental conditioning (Fig. 6).

UNICAMP has several buildings, including old, new and planned, so for that its operations are at their maximum possible, which means we have 100% of the space usage, without conditions influence of its internal operations, it is necessary that these buildings have a routine planning and maintenance. Therefore, this project proposes to analyze the built conditions in energy efficiency parameters [6], so that later we can create a short, medium and long term plan for retrofit, renovation and alteration norms and constructions for buildings (B).

Fig. 6. Label layout for Building Labeling

H. Electricity Procurement

This subproject aims to analyze UNICAMP's contracting of demand and electricity through monthly and daily analysis consumption (A) from the entire campuses and each consumer unit. As the only public university in the country that operates in the free electricity market, UNICAMP has 6 campus, being only the main and largest of them in the free electricity procurement environment, called ACL (in Portuguese). However, after the beginning of this subproject studies, a short term planning was created for the other 5 units also migrate to the ACL.

Other expected products are the forecasting, planning and process redesign tools for the university's electric power contracting (B).

III. Energy Benefits

Over the course of two years of the project, as research and activities progressed, 5 categories of expected and realized benefits were identified, classified according to their complexity, cost and energy gain, as shown in Fig. 7.

At the base of the pyramid occur the simplest actions with the greatest energy gain, considered as Energy Savings. In which, with management actions, continuous improvement, contractual revision and conscious and efficient usage of electro-electronic equipment, the university is able to reduce its consumption by 10% of the current one. At the end of this step, if all actions are recorded and with an efficient asset management, we will have an energy audit for all campus.

With this information it is possible to find the power system weakness and its usage, thus being able to perform the second step. This, depending on the previous step, is responsible for creating zero carbon policies, using previous information and analysis to create norms and standards for the purchase and more efficient equipment use, standard for building construction and operation, among other dependent improvements. of bureaucracy. Even so, this item guarantees the continuity of actions and the change of organizational culture to energy efficiency.

Note that only after the initials steps, finding and cataloging the energy end-use system, making routine use and planning improvements, subsequently recording these changes in norms and standards for usage, purchase and equipment and constructions disposal, which comes the energy efficiency step.

That is, after all this information that old equipment exchanges for new and more efficient, and the new technologies use, such as IoT, are valid. Thus, by thoroughly understanding the reality of the institution and ensuring that future changes are required to be screened, the flow of retrofit will come naturally, and the use of energy efficiency improvements will be more assertive.

With just these 3 steps it is possible to save between 15 to 20% of the university's electricity consumption, with low implementation cost and short and medium term return. But with high demand from people and top management, allowing changes to be encouraged and made.

The fourth step is the application of technologies for renewable energy generation, such as photovoltaic solar power generation, biofuel power generation, among others. This item is high cost, low return and high complexity. That is, for the photovoltaic generation, due to the age of the university, it is difficult to find roofs capable of supporting its installation and to maintain its expected lifetime. Thus, a high cost of roof renovation must happen before the expansion of photovoltaic generation. Still, each year, the university increases at least 50 kWp of photovoltaic installation.

In the case of wind energy, there is no wind in the region that justifies its installation. For biofuel generation, the logistics and the type of biofuel to be used should be studied, being a study for long term implantation (over 10 years).

At the end of the project, we will have enough structure to cause a disruption of electricity within the university. That is, several smart city solutions can be added and tested with short deployment time.

Disruption is based on technologies and applications that emerge after the base infrastructure is solidified and applied, that in this case, it is the electric mobility application. Another expected disruption is the deployment of a micro-network on campus, enabling analysis and integration between solutions for energy efficiency.

IV. Metrics and Deliverables

Throughout this main project, various methods of project management have been applied for research and knowledge management to ensure that the eight subprojects are met and effective. However, several difficulties were encountered, especially at the beginning of the project, which was born without the knowledge and support of top management.

The previous results, such as photovoltaic generation, equipment retrofit benefits and the possibility of improvement with high financial gains in the electricity procurement from all university campuses brought the city hall and top management for support administratively and operationally the project, ensuring its continuity after the end of the research, with the assets absorption at all university structure.

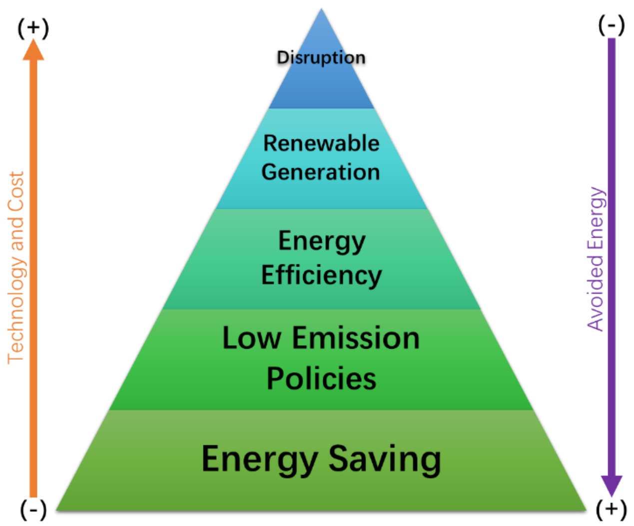

Fig. 7. Energy efficiency pyramid of the Sustainable Campus project.

Therefore, metrics and deliverables were defined for each project year regarding university administration, that is, in addition to the products planned by the research project. Thus, each project's year will deliver a complete retrofit action from an academic institution, as well as increase photovoltaic generation on campus. And with the technical energy management chamber partnership, policies will be created for the acquisition and use of electrical equipment, as well as the university's ten-year energy planning.

V. Conclusion

The Sustainable Campus project's first year was marked by the administrative development of the project, that is, in addition to the installation, implementation and studies of new technologies and research, it was necessary for the project to connect with academic and user administration throughout the university. Without this step the project would not have achieved its current performance and visibility, which was supported by all technical areas and top campus management. The basic steps such as energy management deployment. energy policies, continuous improvement and process changes have only occurred due to this support [7].

Therefore, the application of existing technologies (A) and new innovations (B) on a university campus depends on the participation of the entire community, so that their use is as much as possible. The monitoring and operation center adoption is important, as it is the main structure for the unification of the information generated by all other subprojects and responsible for the interface with users, both administrative staff and researchers.

Finally, for a structured project with various technologies and data generation, it is important to apply knowledge management at all levels of the organizational structure and the project itself, so that in the end the expected success is achieved.

ACKNOWLEDGMENT

This article is part of a project within the Research and Technological Development Program of the Brazilian Electric Energy Sector PD-00063-3032/2017 entitled: PA3032 - "Development of sustainable campus model at UNICAMP – Living lab for applications in renewable microgeneration, energy efficiency and consumption energy monitoring and management, regulated by the National Electric Energy Agency, ANEEL (in Portuguese), and financed by the company CPFL Brazil.

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