Energy management methodology for energy sustainable actions in University of Campinas - Brazil

J G I Cypriano¹, L F Pinto¹, L C Machado², L C P da Silva¹ and L S Ferreira³

1 Energy Systems Department, School of Electrical and Computer Engineering, University of Campinas, Campinas, 400 Albert Einstein Avenue, SP, Brazil
2 Sustainable Campus Office, University of Campinas, Campinas-SP, Brazil
3 Innovation Department, CPFL Brazil Company, Campinas, 1755 Eng. Miguel Noel Nascentes Burnier Highway, SP, Brazil

Email: joao.ito@dsee.fee.unicamp.br, liafaria@dsee.fee.unicamp.br, lui@dsee.fee.unicamp.br, lindi@unicamp.br, luanaferreira@cpfl.com.br

Abstract. Universities need to be open to changes in socioeconomic and environmental that are occurring in the world, to transform society around them. For this, one of the natural movements has been in sustainability, focusing on 2030 Agenda. In this context, this article shows the path that University of Campinas has been adopting in order to become a sustainable benchmark. In the past, there was an environmental movement that culminated in the sustainable policies creation and, earlier, an international commitment to other institutions. Currently, the Sustainable Campus Project is in implementation to develop energy sustainability and change the organizational culture. For the future, the transformations needed to promote a sustainable energy management system and continuous improvement of its actions are indicated. In the end, all those processes will allow a living laboratory in energy sustainability and a regional benchmark.

1. Introduction

In 2015, it was adopted by UN the 2030 Agenda for Sustainable Development with 17 goals, called Sustainable Development Goals (SDGs). The 7th SDG, “Ensure access to affordable, reliable, sustainable and modern energy for all”, has three main targets for 2030, that are: universal access to affordable, reliable and modern energy services; increase the renewable energy generation in global energy; and, double global rate of improvement in energy efficiency. [1]

The Energy SDG is one of the most important goal, because it is interconnected and contributes to achieving 125 targets of the other SDGs (74 percent of all targets), supporting in poverty alleviation, economic growth, expand employment and curb carbon emissions, as shown in Figure 1. [2]

In this context, the University of Campinas is building a sustainable energy living lab in your main campus, Zeferino Vaz’s University City, called: “Sustainable Campus Model at the University of Campinas—Brazil: A Living Lab integrating Renewable Generation, Electric Mobility, Energy Efficiency, Monitoring and Energy Demand Management”; or just Sustainable Campus Project. [3]

This Project was designed to support and promote new solutions to Universities and smart cities, being a regional benchmark case in Brazil and Latin America. Since August 2017, the Sustainable Campus project (SCP) was complemented with three new projects: one in energy efficiency labeling for buildings; another in electricity procurement for free market; and, the last one, in smart meter communication using RF Mesh and LoRa (long range communication) technologies. All these
initiatives and knowledge need a full policy structure to support and maintain those actions in long term.

This article presents the sustainable campus model, which base energy sustainability initiatives and the next steps to continue the SCP’s results, becoming in an energetically sustainable campus benchmark. The section 2, starts with the Unicamp’s history that allowed a sustainable environment growing before Sustainable Campus Project. In section 3, the new infrastructure for measurement and data collection, that will provide a new vision in sustainable energy management, is detailed. The fourth section is about “Energy Management Structure”, modeling the new infrastructure in continuous improvement for energy efficiency actions, including new actors and efficiency indicators. And last, the conclusion and expected results of this review.

![Figure 1. Relationship between Energy SDG and all remaining SDG.](2)

2. Movement towards sustainability

The University of Campinas (UNICAMP - Brazil), with only 52 years old, is known as “research factory” and training center for highly qualified professionals. It currently has 24 teaching and research units, accounting for 8% of all Brazilian academic research and 12% of national graduate studies.

With great representativeness and visibility in teaching and research, the University has been involved in environmental management as own policy since 2003, with the approval of Waste Management Group and Institutional Program for the Management of Biological, Chemical and Radioactive Waste. After waste management initial actions, UNICAMP expanded its sustainability program, creating the Environmental Management Group (GGA in Portuguese) in 2006. Subsequently, an Environmental Management Program was implemented and finally, the Environmental Policy was launched in 2010. In 2012, a technical group in energy efficiency proposed an Energy Management Program to GGA, becoming a future reference to SCP. And, in 2015, UNICAMP signed the ISCN-GULF Sustainable Campus Charter, from International Sustainable Campus Network (ISCN), that organizes a global support forum for key colleges, universities and corporate campuses, exchanging information, ideas and best practices to achieve sustainable operations in those institutions and integrating sustainability into research and teaching. With the signing of this Charter, UNICAMP had publicly committed itself to the sustainability and alignment of its research, teaching and administrative operations with the three principles established by the charter [4], starting the University movement towards sustainability.

Due to the results obtained by GGA, the increasing environmental awareness within the University and the Charter commitment, a broader proposal was formulated leading to the creation of a Sustainable University Management System (SUMS) and a Sustainable University Policy (SUP), with the Sustainable University Manager Group creation. [5]
2.1. Sustainable University Management Group (GGUS in Portuguese)

The SUMS is operated by GGUS and other complementary entities such as the Sustainable University Guidance Council (COUS in Portuguese) and the Technical Chambers (TCs), which should assist in the planning, implementation and management of SUMS, as shown in Figure 2.

The functions of GGUS are: set up, develop and implement policies, guidelines and standards for a sustainable university, based on continuous improvement and environmental, economic and social performance. COUS guarantee and approve the GGUS and TCs’ actions.

The Technical Chambers’ activities are: sustainable management programs and technical procedures elaboration; sustainability performance indicators and institutional goals definition; units’ sustainability reports analysis; and technical reports production.

![Figure 2. SUMS’s Organizational Chart.](image)

There are six technical chambers focused on: Energy; Water; Fauna and Flora; Urban Environment; Waste; and Environmental Education.

2.2. Energy Management Technical Chamber (CTGE in Portuguese)

CTGE is a TC created to improve and implement an Energy Management Program in the Campuses of Unicamp. This program aims to reduce energy consumption through the elaboration of management programs and technical procedures with the participation of all UNICAMP’s entities. [5]

In 2016, CTGE conducted studies in energy management system implementation. Priority projects were modelled to medium-term improvements support in energy use and efficiency. These steps were adopted in the sustainable campus project a year later.

2.3. The Sustainable Campus Project

The sustainable campus project (SCP) is a partnership between UNICAMP and CPFL (local electricity distributor) placed in ANEEL’s (Brazilian National Electricity Agency) R&D and Energy Efficiency program, signed in 2017 [3]. Initially the project started with 6 subprojects, however, three more subprojects have now been added [6], building a sustainable energy cycle around the university (Figure 3).

The subprojects (SPs) are:

- **SP1** – Mini Operation Center (MOC): an intelligent data center for energy and environmental measurement, supporting all SCP subprojects;
- **SP2** – Photovoltaic Generation: 534 kWp will be installed in four different university’s locations;
- **SP3** – Electric Vehicle: implementing a smart electric bus with sustainable recharge station;
- **SP4** – Retrofit (EER): changing old equipment for labeled efficiency equipment;
- **SP5** – Smart Energy Use (SEU): based on IoT sensors to measure internal environmental variables (as rooms and laboratories), in order to promote active energy efficiency actions by users;
• SP6 – Education: trainings, reports and a final book with the compendium of knowledge acquired in the SCP;
• SP7 – Energy Efficiency in Buildings (EEB): energy audit based on the Brazilian building labeling program;
• SP8 – Energy Procurement: electricity purchase in free market;
• SP9 – RF Mesh (RFM): network for transmitting data measured by the sensors.

It is expected that those subprojects will transform UNICAMP in a real Living Laboratory, approaching the academic research and new products development to market needs in sustainable energy solutions.

![Figure 3. Sustainable Campus Model.](image)

3. Improving the path to sustainable energy management

Despite the creation of GGUS and Sustainable Policies, it is necessary that University's management chain be integrated with the sustainable and priority projects applied (such as the sustainable campus project), in order to guarantee the benefits permanence implemented. The SCP is creating a new infrastructure to assure sustainable policies continuity for future projects and daily Campuses routine.

3.1. Infrastructure Construction for Sustainable Energy Management System - SEnMS

Five SCP subprojects will strengthen the SEnMS's infrastructure, with a reliable measurement, data flow and communication platforms. this smart chain will support the university's current demands, future and in progress projects. The benefits are:

• SP1 (Mini Operation Center) is providing real-time measurement per minute, through intelligent meters. The collected data will support decision making in energy efficiency, University's infrastructure and electrical system expansion planning, transformers predictive evaluation, as well as complementary studies developed by research groups in sustainable energy systems.

• SP4 (Retrofit) generated knowledge and expertise through the analysis of replacing inefficient equipment and building verification after and before the retrofit execution. This ensure new energy efficiency projects and a retrofit replication method.

• SP7 (Energy Efficiency in Buildings) is creating a new energy audit methodology for buildings, using: structural analysis, users’ behavior and perception, air conditioning and lighting efficiency. This procedure will contribute to label buildings in energy efficiency and make units more sustainable and environmentally friendly.

• SP5 (Smart Energy Use) will address new concepts in smart buildings and user behavior for energy efficiency daily actions through IoT sensors. This system will be a model of electrical equipment user’s awareness and their comfort and work environment improvement.
- SP9 (RF Mesh) will ensure continuous data flow infrastructure through a reliable communication platform.

3.2. ISO 50001: Energy Management System – Requirements with Guidance for Use
In order to improve energy performance by energy efficiency, use and consumption, ISO 50.001 establishes systems and processes methodologies to be incorporate in organizational infrastructure. The main Standard’s structure is the continuous improvement based on PDCA (Plan-Do-Check-Act), that supports energy policy and energy management [7].

The PDCA must be part of organization context and practiced by all member, following the steps [8]:

- **Plan:** To achieve results that will lead to energy performance continuous improvement, is important the implementation of energy review, baseline establishment, energy performance indicators (EPIs), goals, targets and action plan.
- **Do:** To ensure competency and consider energy performance in the project and acquisition, based on Plan step, here is important realize the actions, operation controls, maintenance and communication expected.
- **Check:** Looking on energy performance direction, this step monitors, measures, analyzes, evaluates, audits and perform critical analysis of previous stages executions.
- **Act:** To solve nonconformity and continuously improve energy performance it is necessary to adopt corrective and definitive actions, besides documenting the acquired knowledge.

The four PDCA steps enhance the Energy Management System, providing routine and knowledge management and ensures sustainable actions continuity in long term. Figure 4 presents an example of PDCA with the implementation of subprojects (item 3.1), in order to incorporate its benefits from the University structure.

**Figure 4. PDCA with Sustainable Campus Subprojects.**

4. Benefits and improvement management structure
In this section, is presented an organizational model for energy management. This new architecture, based on ISO 50001 and supported by Sustainable Campus Project, will benefit the EnMS and strengthen continuous improvement throughout the University structure.

To achieve the sustainable policies intended outcomes, it is necessary include new agents and restructure the academic entities functions, aiming the energy sustainability. The suggested structure model is detail according to action’s priority, on next items.
4.1. Strategic Sustainable Goals
The University's top management in each term, and/or annual reviews, must establish the University's sustainability guidelines, indicating the institution future path and clearly communicating them to the entire external and internal community.

4.2. Sustainable Policies
The GGUS, in its function, should define long-term planning to meet the guidelines established by University's top management, analyzing and suiting them according to Sustainable Policy and, finally, determine objectives and goals for each technical chamber.
Policy modifications, strategic reports to top management and tactical guidelines must be approved by COUS and disseminated to entire external and internal community.

4.3. Implementation
Each technical chamber (TC) will be responsible to regulate goals and targets for all entities, according GGUS's definition. All units must frequently report your results and actions to TCs. In case of CTGE, daily and monthly control metric should be adopted for managerial and operational control, using automatic reports and dashboards for quick actions.
CTGE must be closer to campus energy consuming units, following the continuous improvement actions and results adopted by each entity. Supporting them in training and tools for continuous improvement, daily management, energy efficiency and internal process checking.

4.4. Verification
The verification is necessary to ensure and review action’s result from continuous improvement or upgrading investment. To this, each consumer needs to monitor their process by measuring or regularly variable checking that influence their results. The Mini Operation Center (MOC) will be responsible for energy verification infrastructure and to support all entities in energy consumption M&V.
Studies and energy review of main processes (those that directly influence unit’s energy performance) must be controlled and measured by entity itself. This means that, consumers must deliver a regularly report to CTGE indicating your status, according to MOC metrics and CTGE goals.
Each year, CTGE shall perform an audit in each entity, to verify internal controls (maintenance, assets, equipment calibration, etc.) and nonconformity records, with corrective, prevention and improvements actions. The units themselves can create an internal committee to evaluate the audit items in order to guarantee their own processes.

4.5. Management Review
The COUS has the obligation to: monitor results generated by all technical chambers and GGUS, ensuring guidelines compliance; verify the strategic actions implemented; and sustainable policy review approval.

4.6. Organizational Continuous Improvement
Figure 5 presents the organizational continuous improvement structure, as a chapter synthesis.

5. Expected results
The Sustainable Campus project implementation will leverage the University's energy performance improvement in short-term. To guarantee those benefits in long-term it is necessary brings the University's organizational structure closer together, integrating top management, GGUS, Units and Professionals for a single objective, the Energy Sustainability
With SCP modernization and the initial structure of sustainable management system (SMS) in a strong structure will allow the ISO 50001 Standard application and an EnMS development, in accordance with University's sustainability policy.
Initially, the SCP works as energy measurement and verification infrastructure support (Do and Check methodology) from SMS. Your first data analysis is supporting the initial Sustainable Energy Policy
(SEP) and Sustainable Energy Management System (SEnMS) design (Plan methodology), by Energy Technical Chamber (CTGE). These Sustainable Energy policy and system will provide the planning activities background (Plan methodology). Finally, to complete PDCA cycle, the data, measurement, policy and a real time support system will able continuous improvement practice in daily Unicamp's processes (Action methodology).

As previously seen, subprojects (item 3.1) are extremely important for a new model development of University's energy management and for continuous improvement implementation inside the ISO Standard-based organizational culture. In the end, it will be possible to evaluate energy efficiency actions, use and consumption of energy, as well as to monitor energy performance.

According to [9], around 40% of future energy is expected to be from energy efficiency gains. By that way, a support to allow energy efficiency application and your continuous benefits is necessary. The Standard implementation in the University's processes will encourage and strengthen the continuous benefits in energy efficiency actions, energy use and consumption, through: continuous improvement methodology, processes mapping and traceability of actions carried out. That is, the EnMS ISO-based ensures knowledge maintenance for energy performance into daily operation, changing individual traditional management to cultural business processes.

Through Sustainable Campus Project and EnMS presented in this article, Unicamp will strengthen its living lab in sustainable energy, disseminating and integrating future projects and actions that may be replicated to other universities, cities and isolated communities.
In underway with new R&D and Continuous Improvement projects development, this process will add more structure and knowledge to our living laboratory. This open innovation ecosystem model will integrate users, academia and the market (public-private companies and startups).

5.3. Summary
As mentioned before, this article establishes a linkage between Sustainable Campus Project to ISO 50001, using one to support another, as example: measurement SCP structure with ISO performance baseline; Standard protocols to sustain energy efficiency actions; SCP organizational architecture to EnMS implementation; and continuous improvement to Sustainable Energy Efficiency in long-term. Initially, SCP brought low-cost results that are launching the EnMS implementation in UNICAMP. In other words, before all SCP's infrastructure installation and only with energy efficiency idealized movement, some observation-based actions improved equipment retrofit benefits[10] and increased the top management interest in energy sustainability. In two years, we will have an integrated EnMS that can be used by another institutions, with low-cost execution.

6. References
[1] PNDU and IPEA. "2030 Agenda Platform". [Internet]. [Accessed September 2018]. Available from: http://www.agenda2030.com.br/.
[2] World Bank. 2017. State of Electricity Access Report. (Washington DC: World Bank Publications).
[3] L. C. P. da Silva, et al. 2018. Sustainable Campus Model at the University of Campinas—Brazil: An Integrated Living Lab for Renewable Generation, Electric Mobility, Energy Efficiency, Monitoring and Energy Demand Management. Towards Green Campus Operations. ed Springer. pp 457-472.
[4] University of Campinas. ISCN/GULF Sustainable Campus Charter. [Internet]. April 2015 [Accessed September 2018]. Available from: http://www.ggus.depi.unicamp.br/wp-content/uploads/2017/01/ISCN.pdf
[5] GGUS. Sustainable University Management Group. [Internet]. UNICAMP. [Accessed September 2018]. Available from: http://www.ggus.depi.unicamp.br
[6] GGUS. Sustainable Campus Project. [Internet]. UNICAMP. June 2018 [Accessed September 2018]. Available from: https://www.campus-sustentavel.unicamp.br
[7] ABNT. 2011. NBR ISO 50001: Sistemas de gestão da energia – Requisitos com orientações para uso. (Rio de Janeiro: ABNT).
[8] ABNT. 2018. NBR ISO 50001: Sistemas de gestão da energia – Requisitos com orientações para uso. (Rio de Janeiro: ABNT).
[9] International Energy Agency. 2014. Energy Efficiency Indicators: Fundamentals on Statistics. (Paris: OECD/IEA).
[10] Procel. Results from: Chamada Pública Procel Edifica 2018. [Internet]. Eletrobrás. February 2018 [Updated: August 2018, Accessed: September 2018]. Available from: http://eletrobras.com/pt/AreasdeAtuacao/Chamada_Publica_Procel_Edifica/Lista_de_Classificacao_Final_Chamada_Publica_Procel_Edifica_2018.pdf

Acknowledgments
The National Council for Scientific and Technological Development (CNPq in Portuguese) has supported this work financially. Opinions, premises, conclusions and recommendations expressed in this document are those of the authors and do not necessarily reflect the opinions of the CNPq. This work was developed under the Electricity Sector Research and Development Program PD-00063-3032 / 2017 - PA3032: "Sustainable campus model at the University of Campinas - Brazil: An integrated living lab for renewable energy, electric mobility, energy efficiency, monitoring and energy demand management", regulated by the National Electricity Agency (ANEEL in Portuguese), in partnership with CPFL Brazil (Local Electricity Distributor).