Development of a methodological framework for Técnico Alameda Campus as a Living Lab focused on Entrepreneurship and Energy

Adriano Candeias Martins
adriano.c.martins@tecnico.ulisboa.pt

Instituto Superior Técnico, Universidade de Lisboa, Portugal

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Abstract

This thesis aimed to analyse Living Labs or sustainability projects developed in universities, and, subsequently, present a proposal for the creation of a Living Lab on the Alameda Campus of Instituto Superior Técnico, the Campus as a Living Lab (CALL). Climate change and the evolution of Industry 4.0 represent new responsibilities and tools, respectively, for solutions achievement.

The Alameda Campus was contextualized (services and infrastructures), as well as the sustainability initiatives developed there. Next, suggestions for organizing the governing structures were presented, and the measures already taken to disseminate the CALL were described, including the creation of a website and propagation of the initiative. The structure of the CALL was characterized as a multi-layer platform, which is associated to technologies, services, and devices for solutions related to energy sustainability. Mechanisms were suggested to attract partners for the CALL, which involve collaboration between the CALL and the Technology Transfer Office. Finally, a case study involving the conversion of Pavilhão de Informática II into "Net Zero Building", through the installation of photovoltaic panels and batteries, was developed.

As a result, this document can be interpreted as a guide for implementing the Living Lab concept at the Alameda Campus. It should be noted that this approach represents a personal proposal of what the Campus as a Living Lab could be, and that, as such, the development of future proposals by other members of the Técnico community could be interesting.

Key Words: University Living-Lab, Sustainable University Campus, Entrepreneurship for Sustainability, University-Industry Partnership.

1. Introduction

1.1 Motivation

In the last decade global warming manifested with an increase of the surface global temperature of 0,82℃ over the 20^{th}century average[1]. The greenhouse gas emissions, that play a significant role in climate change, reached in 2019 a new high record of $52{,}4\ GtCO_2e$ (without land use)[2]. These tendencies lead to an increased occurrence of extreme natural events such as wildfires, floods, droughts, rising sea levels and, water scarcity, to name a few. The existence of such events puts people and biodiversity directly at risk and affects the quality of life on earth. There is an urgent need for action to minimize the consequences of climate change, meaning that sustainable development of society must be pursued.

1.2 Sustainability

A sustainable development aspires to allow progress in a way that satisfies the needs of the present generations without compromising the capacity of the futures generations to satisfy their needs [3], while ensuring the ecological, economical, and sociocultural dimensions of sustainability are taken into account.

1.3 UN SDG

It was estimated that there were approximately 30 million climate refugees across

135 countries in 2017, and it is estimated that this number can increase to 143 million by 2050 if no actions are taken to mitigate climate change[4]. Measures have been taken to address concerns related to climate change and pursue sustainable development across the globe, thus, in 2015, the United Nations (UN) set the 17 Sustainable Development Goals (SDGs), to tackle climate change and preserve oceans and forests, while aiming to improve health and education, reduce inequality, and stimulate economic growth [5]. Also in 2015, the 21^{st} Conference of the Parties in Paris, 2015, culminated in the Paris Agreement, an international treaty developed with the purpose of limiting Global Warming to a maximum of 2°C, compared to pre-industrial levels [6].

1.4 The need for Action – Starting as a student, based in science.

Universities are accountable to educate tomorrow's leaders. This education is not limited to preparing the students to execute a profession. The universities shape the way that students observe and absorb information around them and influence their interaction with the world. The need for action regarding climate change requires the inclusion of values and concerns in education. The universities represent platforms where solutions to real-world problems can be developed and tested. In other words, universities can be seen as testbeds to develop products, services, and technologies that can solve problems with and for the community.

This approach leads to the concept of Living Lab, which is defined in "*A Milieu for Innovation – Defining Living Labs*" as a user-centric innovation milieu built on everyday practice and research, with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-life contexts, aiming to create sustainable values [7].

1.5 Técnico Living Lab

Institutions as Instituto Superior Técnico (IST) represent a diverse community that works to educate and research, being seen as an active and significant voice among the scientific and social community. With this dimension and impact comes the responsibility of striving for a better future, a future that is sustainable, by aiming towards the 17 SDGs. The Campus as a Living Lab (CALL) is intended to be a contribution in that sense. The goal is to create a platform where ideas to make the Alameda Campus a better place can be shared and eventually developed, while simultaneously inviting all members of the Técnico community (Students, Professors, Staff, Researchers) to participate.

1.6 Objectives

This thesis aims to develop a guide on the implementation of the CALL in Técnico Alameda. To do so, research on the governance models being used in other Universities, and the influence of the activities being developed was performed. Also, there is the need to design the CALL, whether it is by listing all the assets associated to it, and how they can be involved in the development of tests and research with partners, or by designing the scenarios to stimulate the creation of partnership with external entities. Finally, this thesis also provides a practical example of a Living Lab that can be developed in Campus, a Net Zero Building.

2. Establishing the concept of a University Living Lab – Literature Review

Research was performed on the concepts of University Living Lab, Sustainable University Campus, Entrepreneurship for Sustainability, and University-Industry Partnership. Emphasis was put on Universities that developed Living Labs and provided information about it on their websites or scientific papers/reports.

Genoa University developed, with partners, "Energia 2020" at the Savona Campus. This

project is funded by the Ministry of the Environment, the Ministry of Education and the Liguria Regional Administration, with a budget of 8 million euros [8]. The university hosts more than 32 000 students and 1335 postgraduates. “Energia 2020” a pilot experiment of a Smart Sustainable City, is intended to be an “innovative and high performance building to meet goals of zero carbon emissions, energy and water efficiency and building automation” [9]. The approach of Smart City is applied through different projects developed simultaneously, the Smart Energy Building (SEB), the Smart Polygeneration Microgrid (SPM), Energy efficiency Measures (EEM) and a Smart City Demo.

The University of British Columbia (UBC) has two campi, and a total of 66 512 students, where 55 161 are undergraduate and 11 351 are graduate, divided by UBC’s 16 faculties and 18 schools [10]. The UBC’s annual budget typically sits around 3 billion $, with approximately 40% of it is coming from government grants and contracts, 30% from tuition and student fees, 15% from sales and services, 7% from non-government grants, contracts and donations, 3% from investment income, and 3% from deferred capital contributions. UBC claims that there are around 672.7 million $ available in research funding for 9,941 projects [10]. Three different projects were developed, resulting in to actively tackle the emission: The Centre for Interactive Research on Sustainability (CIRS), consisting of a building that can be used as a Living Lab and a net-positive energy producer and net-zero carbon building [11]; the Academic District Energy System, a project to convert the heating system of 131 buildings across the campus from steam to hot water [11]; and is the Bioenergy Research and Demonstration Facility, which goal is the reduction of imported power on campus by using a renewable source for fuel [11].

Wageningen University and Research (WUR) is a Public Research University with 13 275 students, of which, 6 037 are bachelor’s students, 6 939 are master’s and 2 183 are PhD Candidates [12]. The total income of the WUR for the last 3 years typically varies from 362 million € to 385 million €, where approximately 55% comes from government funding, 11% from bilateral market, 10% from tuition fees, 9% from research funding and targeted subsidies, 5% from co-funding and matching market revenue, and 10% from other sources [13]. WUR implemented a Living Lab approach to make “students of the master’s Metropolitan Analysis, Design and Engineering (MSc MADE) work on real-life cases within the city of Amsterdam“ [14], regarding six urban challenges: Smart Urban Mobility, Urban Energy, Climate Resilient Cities, Metropolitan Food Systems, Responsible Urban Digitization, Circularity in Urban Regions. The Living Labs are developed and governed by MSc MADE students.

The Universidad Politécnica de Madrid (UPM) is a Public University englobing 4 campus, 18 Schools/Faculties and 17 Research and Development Centres. It has approximately 35 700 students in bachelor and masters’ programmes and 1 900 doctoral students. There are as well 200 research groups and 71 Industry-University Endowed Chairs. Data from 2019 indicates a Total Budget of 320,8 million €, with 91,5 million € from tuition and fees, 213,5 million € from public financing, 4,05 million € from private financing and 11,6 million € from international funding. The research is sponsored with 19,1 million € from public national funding, and 3,7 million € from contracts with private industry [15]. The UPM participated in a partnership, “Alianza Shire”, to provide energy access to refugees and displaced people. This initiative not only covers the improvement and extension of the electricity grid, installation of LED luminaries for street lighting, it has a training and participation principle [16] . The goal is to train refugees from the camp to be able to do the maintenance of the installations.

Harvard University is a Private Research University with 12 Graduate and Professional Schools and one Institute. Data from the academic year of 2018-2019 indicated that the

university had 31 566 students, with 9 950 in undergraduate courses and 21 616 in graduate courses [17]. The financial overview indicates for 2020 an Operating Revenue of 5 400 million € with the following sources: 37% endowments, 17% Education/tuition, 17% Research, 9% Gifts, 20% Other [18]. Harvard University has developed some initiatives to develop solutions towards a more sustainable campus: the Campus Sustainability Innovation Fund, a $700,000 fund to support student research projects that tackle challenges faced directly on campus or in the community, and lead to the application of new sustainability strategies [19]; the Climate Solutions Living Lab Course and Research, a three-year, multi-disciplinary course and research project led and designed by Harvard faculty to study and implement practical solutions for reducing greenhouse gas emissions; Student Grants to provide seed funding for student projects that contribute to Harvard's commitment to climate and health, and which help create a more sustainable campus community [20].

Massachusetts Institute of Technology (MIT) is a Private Research University. It is divided in 5 Schools and 1 college across an urban campus. There are 11 520 students at the MIT, 4 530 of them being undergraduate and 6 990 graduate [21]. For the year of 2019 the total operating revenues were 3 932 million $ and the sources were: research – Lincoln Laboratory 27%, investment return 22%, research – Campus 19%, gifts 10%, tuition 10%, other operation 8%, auxiliary enterprises 3% and research – Singapore MIT alliance 1% [22]. The MIT Office of Sustainability (MITOS) is responsible for the development of a living lab and sustainability related activities in campus, creating projects in 5 areas [23]: Zero-Carbon Campus - activities regarding climate, buildings, energy and mobility , Climate Resilience - activities regarding planning, climate risks, education and resilient ecosystems, Material Life-Cycle - activities regarding procurement, waste and re-use, Healthy People - activities regarding food and environmental justice, and Thriving Networks - designing the partnerships to advance in sustainability. To stimulate the development of activities in the mentioned areas, the MITOS created a course “Solving for Carbon Neutrality” [24] and a fund “Incubator Fund” [25].

TU Delft is a Public University composed by 8 faculties, with a total of 26 480 students. There are 13 806 bachelor’s students, 12 435 master’s students and 2 921 PhD students[26]. TU Delft Annual Report 2019 presents a total income of 762 million € with the following sources: 439 million € from government and other contributions, 216 million € from projects with third parties, 73 million € from tuition and examination fees, and 34 million € from other sources [27]. In collaboration with Stichting Green Village, TU Delft rehabilitated a building to create The Green Village, with the goal of allowing knowledge and educational institutions, entrepreneurs, government bodies, and civilians to research, experiment, validate, and demonstrate innovations for a sustainable future [28]. Activities are developed in 3 different themes [29]: Sustainable Building and Renovation, Future energy System and Climate Adaptive City.

As expected, for the public universities in analysis, UBC, WUR, UPM and TU Delft, the main sources of financing are Government/Public funding, tuition fees, and research/services performed.

The private universities, Harvard University and MIT, shown that their bigger sources of financing are endowments, research and tuition fees.

The analysis of the activities developed on the universities above described allows to conclude that the projects can be divided in 2 parts: Top-down and Bottom-up.

The projects/initiatives following a Top-down approach are normally designed and implemented by the governance or the office for

sustainability of the university. This approach is common to all the analysed universities.

The Bottom-up approach corresponds to the development of projects/initiatives by students, researchers, professors, or staff members. This approach requires measures to empower all the members of the community to act. From the analysed universities, UBC, WUR, Harvard University, MIT, and TU Delft are the ones that implemented strategies to stimulate this type of approach. Coincidentally, except for TU Delft, those universities are the ones that presented a higher budget per student.

The Literature Review leads to conclude that a university following both types of approaches represents the ideal scenario to stimulate Living Labs and sustainability related activities. Figure 1.6.1 illustrates the connection between the two approaches.

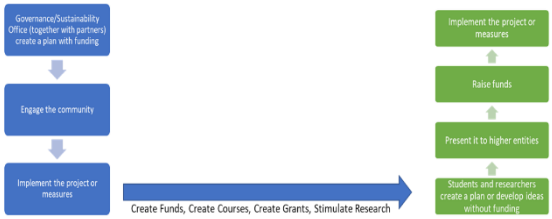


Figure 1.6.1- Connection between Top-down and Bottom-up approaches

Figure 1.6.1 illustrates in the blue part the Top-down approach, consisting of the design and implementation of measures by the governance. The green part represents the Bottom-up approach, with the development of ideas from students and researchers, the presentation of the idea and fund raising to support it, to finally implementing it. The arrow between the two approaches represents the required "tools" to connect both approaches. The creation of funds, courses, grants, and research stimulation has shown to be effective in involving all members of the community in the development of sustainability related activities.

3. Status of Energy Management and Entrepreneurship activities at IST

3.1 Context

IST is the biggest Engineering, Architecture and Technology School in Portugal, with 3 campi and a total of 11 339 students, 5 776 bachelor's students, 4 459 master's students and 1 104 PhD students. IST offers 19 bachelor's programmes, 32 master's programmes and 33 PhD programmes. The CALL is to be implemented at Técnico's Alameda Campus, located in the centre of Lisbon. This campus is composed by 26 buildings, which are used for administrative activities, teaching, investigation and development, and support activities, such as restaurants, bars, and canteens. The area of the campus also includes outdoor spaces and parking places.

The IST's Statistics and Prospective Unite emitted in May 2021 the "Facts and Numbers" of the IST [30], declaring an annual budget of 107 million €, of which 51% are from self-funded. This results in an annual budget per student of approximately 9 500€. When comparing this value with the values of budget per student at other universities it is evident that the IST's budget is one of the smallest. The only University presenting a smaller budget per student is UP Madrid, with approximately 9 000€/student. The analysis of the type of approach followed at IST reveals that the there is only a Top-Down approach. The activities related to sustainability developed in the campus are managed by the Energy Initiative and the Governing Board. There are no funds, courses or grants created specifically to stimulate and engage the community in establishing new activities.

3.2 Services and Infrastructure

The services that the Alameda Campus provides other services than teaching and research related activities, such as alimentation services, analysis laboratory, banking services, congress centres, health services, sport facilities, among others. This leads to a wide diversity of equipment being needed to operate the campus. In the context of "*Técnico - Campus Sustentável*" [31], an energy audit was performed to later

implement energy efficiency measures. The audit resulted in an inventory of all the equipment existent in the campus, with its classification according to the following categories of equipment: HVAC, Computers, Common Systems, Catering, Electrical plug-in, Lighting, and Research. The audit allowed to trace the energy (electricity and gas) consumption of every building of the Alameda Campus. This information can be an asset on Living Lab development, as there is a broad type of equipment and data concerning energy consumption on the campus that could be useful, especially for industry-partners to test services and technologies in a real-world scenario.

3.3 Energy Initiative and the Sustainable Campus Project

Energy sustainability in IST is mainly addressed by the Energy Initiative. The working group dedicates to optimize the use of resources in the campi. Since it was funded, some achievements were made regarding different areas:

- Electrical Energy consumption: measures such as sensibilization of staff members, introduction of low activity periods, installation of electricity meters, among other resulted in a reduction of 16% in electrical energy consumption between 2011 and 2018, representing over 1,7M€ savings across the same period [32]. The actions also resulted in the creation of EnergIST, an online platform where the energy consumptions can be consulted by Técnico's community members.
- Water-use: measures as installation of water measurement systems, rapid response to failure occurrences, increased maintenance in water networks, among other, resulted in approximately 58% water savings between 2011 and 2018, which can be traduced in 387 426 $m^3$of water and over 1M€ od accumulated savings.
- Sustainable Mobility: two initiatives were developed regarding mobility – "U-Bike Portugal – Operação Técnico" and a Carpooling platform, with the first one regarding the attribution of bicycles to community members at an affordable price, the creation of bicycle parking spots, and a workshop. The carpooling platform allows the users to share car rides to Técnico.
- Residue treatment and recycling: this theme was addressed by differentiate the waste collection, community sensibilization, and establishment of contractual clauses to lead suppliers to take responsibility in sustainable waste production and management.

3.4 IST Partners Network

Técnico Technology Transfer Office oversees Técnico Partner Network, meaning this office is responsible for the establishment of partnerships with external entities. The partnerships are characterized by five dimensions[33]: Meeting New Talents, More and Better Talents, Innovation Accelerator, Social Responsibility and Participation in Orientation of IST Strategies. There are different levels of partnership, leading to different benefits according to the value of the contribution made by the partner.

The Core for Corporate Partnership is the responsible entity for the partnership with Industry Partners.

4. Developing strategies for IST Campus as a Living Lab on Energy and Entrepreneurship: The CALL initiative.

4.1 The Governance

The CALL is a creation of the Energy Initiative of IST. The Energy Initiative is a transversal structure in the governance model pf IST, which means it develops activities that influence different courses, departments, and investigation units. The core for Corporate Partnership from the Technology Transfer Office is not connected to the transversal structures in the governance scheme. To stimulate the creation of partnership, a direct communication between

the CALL and the Core for Corporate Partnerships would be important, as suggested in Figure 4.1.1.

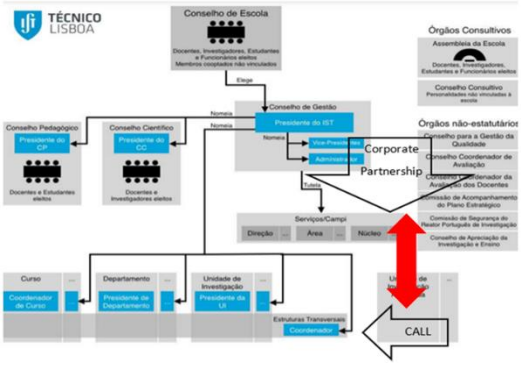


Figure 4.1.1-Insertion of the CALL in IST Governance Structure

For the CALL itself, a governance structure with 2 departments is suggested: Living Labs and Partnerships. The Living Labs department can be divided in several Living Labs, each one with an autonomous administration and project development team. The partnership department is the entity of the CALL that oversees communication with the Technology Transfer Office.

4.2 Identifying and Mapping

The actions to acknowledge Técnico community about the CALL started with the creation of the website (https://callforenergy.tecnico.ulisboa.pt/), where the CALL is presented, and the community members are invited to join the activities. Later, in June 2021, an email with a form was sent to all the students of IST. The form invited the community members to join the CALL and submit Living Lab ideas. Approximately 25 responses were obtained, mainly from students and researchers. The ideas were later organized in three different themes: Sustainable Practices, Energy Conversion, and Mobility. Then, IST Professors collaborating with the CALL presented the structure of the CALL as a Multi-Layer Platform. There are five core layers, see Table 4.2.1.

Layer	Content
Environmental Layer	Environmental Impact; Weather Conditions;
Social Layer	Social Interaction; User Behaviour
Cyber Layer	Big Data Analytics; Artificial Intelligence
Data Exchange Layer	Data management/storage; Cyber security
Physical Layer	Sensors; Meters; Actuators; Energy Devices

Table 4.2.1- The 5 core Layers and respective content

Two additional Layers were suggested as transversal Layers: The Business Layer and the Research and Development Layer.

A Living Lab Characterization criterion was also created. The objective is to set dimensions to objectively identify and present the Living Labs once they are being developed. The suggested dimensions are:

- Theme: Energy Conversion, Mobility or Sustainable Practices.
- Personnel: Who leads and develops the Living Lab.
- Technologies: Technologies and services involved in the activities.
- Infrastructure: Infrastructures involved in the Living Lab.
- UN Goals: UN Sustainability Goals being addressed by the Living Lab
- Funds: The Budget for the Living Lab.
- Partnerships: Who supports the Living Lab.
- Outcomes: Impact/outcomes of the Living Lab.

To a clearly identify the Living Lab and the Layers of the Multi-Layer platform being addressed by it, the dimensions can be related to the Layers previously described.

4.3 Aligning ideas and financing sources – Promote industry-university relationships

The large diversity of services and infrastructures offered by the Alameda campus, as well as all the data associated to the users of the campus, represent a wide range of possibilities to use the Campus as a tested bed for new solutions, as expressed in Figure 4.3.1, adapted from[34].

Figure 0.2- Use of the Campus as a Living Lab, from [34]

The CALL needs partners to provide either financial or material support for the development of Living Labs, either for direct intervention in the activities or to create the "tools" to stimulate the development of Living Labs, represented in the arrow in Figure 1.6.1.

The CALL can develop different types of Partners and Partnerships, see Figure 4.3.2.

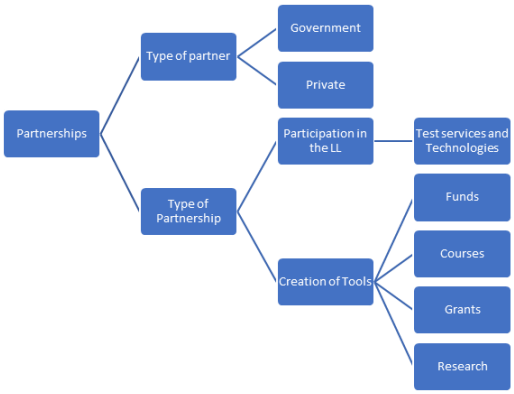


Figure 0.1-Types of Partners and Types of Partnerships

Industry/Private Partners: to this partners the CALL can be presented as a sixth dimmension in the partnership dimmensions stipulated by the Technology Transfer Office.

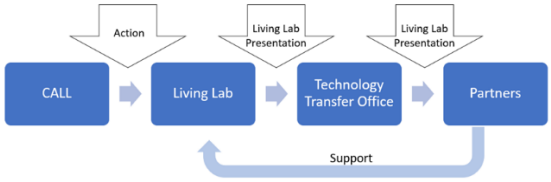
Public Partners/Government: The Portuguese Government faces a Recovery and Resilience Plan (RRP) for mitigation of socio-economic impacts of COVID-19, there is an intention to apply funds towards Digital Transition, being that one of the measures to do so is the creation of a National Test Beds Network. The RRP dedicates 450 M€ to Digital Transition of Companies, which include the creation of a National Test Beds Network.

4.2.1 – Collaboration between the CALL and the Technology Transfer Office

A direct collaboration between the CALL and the Technology Transfer Office, especially the Core for Corporate Partnership, is important to maximize partners engagement, and it represents a situation of mutual benefits. The interaction can occur:

1) CALL to Technology Transfer Office (Core for Corporate Partnership):

This type of interaction will occur when the CALL will be developing a Living Lab

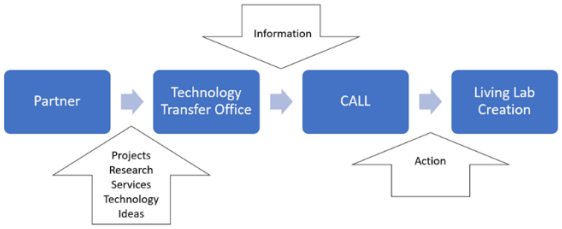


and request the Technology Transfer Office for partners to support it, Figure 4.3.3.

Figure 0.3-From the CALL to the Technology Transfer Office to engage partners

2) Technology Transfer Office (Core for Corporate Partnership) to CALL:

This type of interaction will happen when a partner approaches the Technology



Transfer Office with an idea of a Living Lab to develop or the need to test a service or technology, Figure 4.3.4.

Figure 0.4- From Partners to the Technology Transfer Office to use the CALL

5. Analysis of a case study

The case study consists of the conversion of Pavilhão de Informática II into a Net Zero Building with the installation of a photovoltaic (PV) system and batteries. The roof features a

usable area of approximately 420 m^2. The data regarding electrical energy consumption selected for the dimension of the PV system corresponds to the year of 2019, as it was the last year before a reduced occupation of the campus due to the COVID-19 pandemic. The energy consumptions were registered by EnergIST.

5.1 Data Collection

A Photovoltaic Geographical Information System from the European Commission was used to obtain the solar irradiance on the roof of the building [35]. The profile of the solar irradiance was compared to the energy consumed per month to identify the months with higher energy consumption and lower solar irradiance values. The months of January and December were identified, and the day with the highest energy consumption of each month was selected.

5.2 PV system sizing

The Equation 1 was used to determine the required area of panels.

$$E[Wh] = \Delta t[h] \times \eta[\%] \times A[m^2] \times G\left[\frac{W}{m^2}\right] (1)$$

Where E represents the energy output, Δt represents a time interval, η is the efficiency of the PV system, A is the area of PV panels, and G the solar irradiance. The efficiency was obtained from the datasheet of the considered Photovoltaic module, LG NeON2 – 350W [36], and is equal to 20,3%. As the required energy output is known from the EnergIST data, the area can be calculated through Equation 2.

$$A = \sum_{i=1}^{24} \frac{E_i}{\Delta t \times \eta \times G_i} (2)$$

The Equation 2 allows to obtain the required area to produce the required energy for a full day. The results in Table 5.2.1 were obtained.

	January	December
Area [m^2]	119,9	122,9

Table 5.2.1-Required areas calculated for January and December

The energy production and consumption profiles for December (critical month) are represented in Figure 5.1.1. The area of 122,9 $m^2$is the minimum area that guarantees that the energy production covers the energetical needs, which means that the area 3 represented in Figure 5.1.1 is equal to the sum of areas 1 and 2. This

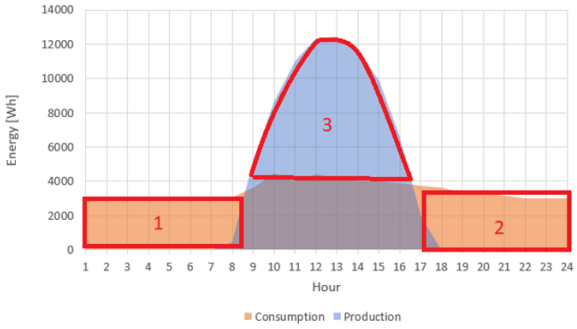


Figure 5.1.1- Energy Consumption/Production for December

represents the need of 71 photovoltaic modules.

The battery capacity corresponds to the sum of areas 1 and 2, which in this case, for the critical moth, December, is 52,6 kWh.

5.3 Financial Analysis

To perform the financial analysis, it was assumed that the electricity has a cost of 0,14€/kWh. Each PV module costs 300€ [37], the battery cost was estimated to be 500€/kWh[38][39], a cost of 15% of the battery cost was considered for the battery management system and the inverter. This represents a total investment of 51 545 €. The results of the investment suggest apay-back time of 18,31 years.

6. Conclusions

The analysis performed revealed that the creation of funds, courses, grants, and research stimulation are directly related the amount sustainability initiatives.

The design of the CALL and its presentation to the community via website and email resulted in the obtention of Living Lab ideas, mainly from students and researchers, leading to the inclusion of younger members of the community, that often come-up with new and creative solutions,

with experienced professors that entail a plenty of experience and know-how on various subjects.

The articulation between the CALL and the Technology Transfer Office envisions a situation with mutual benefits. The CALL can rely on the Technology Transfer Office to find help in creating partnerships to support Living Labs, while the Technology Transfer Office can make use of the CALL to attract partners to Técnico Partners Network, presenting as a new dimension in the partnerships where the partners can research and test technologies and services in a real-world scenario.

The conversion of Pavilhão de Informática II into a Net Zero Building revealed some limitations, especially regarding the sizing of the battery system to allow the building to operate when the photovoltaic system is not converting energy, resulting in project possibly financially non-viable. However, a solution could be achieved by collaborating with a partner interested either in introducing an Energy Management System to reduce and optimize energy consumption and thus minimize the required battery capacity, or in using this Living Lab to test alternate battery solutions, as battery development is nowadays an area of interest in the development of solutions for sustainable energy production, storage, and use.

Finally, it is possible to complete that the future work to be done starts by implementing the measures presented in this document. The CALL, in collaboration with Técnico' governance must be clear in communicating to partners "What we have to offer" and "What we need" in exchange, thus, promising solutions for all the involved parts will be achieved.

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