Integration and Intelligence for Sustainability - I2S

An overview of the I2S Intelligent Building's concept from the Campos dos Goytacazes Innovation Hub campus.

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***Abstract*—This paper presents an overview of the Integration and Intelligence for Sustainability concept or better called I2S. The system will be installed in the Campos dos Goytacazes Innovation Hub (PICG) campus of the Instituto Federal Fluminense, and the project aims to integrate the data generated from different subsystems, mainly the renewable energy generation system, energy consumption, water treatment plant, sewage treatment plant, etc. As the PICG, since its creation, has always been focused on being an environmental friendly campus, the data acquired in the I2S system will make possible the reduction of operation cost, besides providing for users and researchers data for future projects in the campus, and also making them have critical thinking about resource's consumption, making the campus an example of sustainability for the society around.**

Keywords—Smart Campus; Systems; Monitorement; Sustainability;

I. INTRODUCTION

Water and Energy are fundamental factors for development and well-being worldwide. For being important resources for human life, along with the food demand, the shortage of this resources and the climatic changes are making the entire world discuss ways of using them more efficiently and ways of sustainable development. Justifying this concern, the World is facing a scenario where its population has a growth projection of 1.2 Billion people up to 2030, reaching a total of 8.5 Billion of people[1]. In the same way the demand of water and energy have a growth projection, in the same period, of 40% and 50% respectively[2].

Considering those projections, and the current scenario of consumption growth, the World is each day more worried about global warming, making a better usage of resources as water and energy is even more necessary. Building processes that mitigates the waste of those resources, in order to maintain quality standards, besides ensuring efficient consumption methods for users all over the World constitute a challenge for the World community, because, in order to achieve these goals of eco-efficient systems, new technologies become essential for this development.

A concept that emerged in the 80's that aims a better usage of this resources, maximizing its technical performance at the same time that reduces operating costs were the Intelligent Buildings[3]. The intelligent buildings' concept have been changed over the years, never discarding the previous concept, and according to Wong et al. [3] the first definitions were focused primarily on the technological aspect of the system. In one of the first definitions, the Intelligent Building Institution in Washington (1988, cited in Refs. [3,5]) defined intelligent building as ‘one which integrates various systems to effectively manage resources in a coordinated mode to maximize: technical performance, investment and operating cost savings and flexibility'.

Further, the definitions have started adding some social aspects as the importance of the building taking care of the well-being of its occupants. Health, wellbeing and comfort are all important and the intelligent buildings are indispensable in helping to achieve this by upgrading human resources, by providing environmental systems which support the productive, creative, intellectual and spiritual capacities of people[5,6]. Recent researches [7,8] suggest that 'the intelligence embedded into Intelligent Buildings are claimed to enable them to be highly responsive to users’ needs, the environment, and the society, and to be effective in minimizing the environmental impacts and natural resource wastes', giving more importance of being environmental friendly and now working on three fundamentals approaches technological, social and environmental.

Based on those concepts presented, emerged the concept of I2S, an project that is getting form at the Instituto Federal de Fluminense's campus Campos dos Goytacazes Innovation Hub (PICG). The PICG has always been a campus focused on sustainability, and I2S project is being built to maintain this characteristics and be an example of sustainability for users and the society around.

The I2S, in this first moment, will be a system that integrates the information acquired of others subsystems, as energy generation, energy consumption, fresh water and sewage treatments, among others. The data acquired by the system will be treated and shown in a panel installed in the building, so that users can see all information, and beyond that stored for further analyses and research. The objective of this paper is to present an overview of the I2S project and also present a systematic review of intelligent campuses worldwide.

II. INTELLIGENT/SMART CAMPUSES

The Intelligent or Smart Campuses follows the same concept of Intelligent Buildings presented before, providing processes efficiency and creating an harmonious ambience between users and environment and it is each day more in evidence as much as Intelligent Buildings, what can be seen on recent researches shown next.

Abdrabbah et. al [9] on their work emphasizes the social aspects of the smart campuses, and how it can contribute on the quality students' life, citing the necessity of the campus to have a system able to identify the students' requirements and to be adaptable to reach them. The work proposes a solution based on a group recommender system of students' social activities, allowing them to express their preferences, presenting a experimental study carried out an real-world data, showing the results of the proposed recommender system.

Adamkó [10] on his work "investigates software systems and related aspects of this evolution to introduce an open architecture easily extensible service" applied to intelligent campuses. He states that these services increases the smartness level of the campus, and presents three directions of aspects and technology to enlarge the quality of campuses services as IoT (Internet of Things), cloud and ubiquitous computing to make the services available everywhere, and pointing the University as a "proper place where all this new technologies can be examined and applied continuously as a sustainable evolution".

Uskov et al.[11] aims, on his work, "to develop smart university concepts and models, and identify the main distinctive features, components and systems of a smart university". In order to achieve that, make an extensive bibliographic research to present the up-to-date outcomes and findings of conceptual modeling of smart university, helping traditional universities understand the strengths, weaknesses, opportunities and treats of becoming a smart university.

Gleizes et al.[12] present on their work the Neocampus' project, detailing the infrastructure deployed in an University in Toulouse, France. As the author represent the smart campuses as a perfect place to experiment integrate innovative applications and technologies to improve the quality life of smart cities' citizens, the work presents a report of the main challenges a smart campus has to deal with in its implementation.

Malatji [13] on his work presents a smart campuses' point of view from African universities. The work shows an important characteristic of smart campuses and buildings, that each project and each region has its peculiarity, and on this paper he shows that European systems' must be modified in order to suit African universities, in the same way that exhibits a case study of a South Africa university, showing the strength and shortcomings of this campus becoming a smart campus.

III. INTEGRATION AND INTELLIGENCE FOR SUSTAINABILITY - I2S

A. Overview

The I2S system will integrate five subsystems, that will be shown bellow. Although the system in this first moment will work just monitoring the data from the subsystems, it's already being designed to be upgraded and in a near future be also able to realize the subsystem's control aiming further that the I2S become an autonomous system, managing all of the campus' parameters and consumption and that the PICG become self-sufficient of external resources.

B. I2S System

The present efforts of the project is to built the architecture of the system and also standardizing the communication of each subsystem with the main system. The I2S system is being built to be a distributed system capable to add extensions or subsystems. As the subsystems are independent projects, each new project will be able to connect with the I2S system utilizing the I2S pattern, having it data available for users independently sensors or technology applied on them.

One technology that will be installed to monitor some subsystems are the Smart Meters. The Smart Meters, as the name suggest, are intelligent sensors developed in the PICG's laboratory and produced in the own campus by LEBio's team. Currently, there are two types of Smart Meters produced, the Smart Flow Meter and the Smart Power Meter. The Smart Flow Meter is a smart water consumption management tool that can provide information such as instantaneous flow, volume consumed over time and consumption graphs, as well as being able to generate automatic reports of consumption data, making projections and be an important tool to aid in the detection of leaks. The sensor operates in a flow range of 1 - 30 liters / min, with a maximum operating pressure of 2 MPa and a working temperature that can range from -25 to 80 ºC.

The Smart Power Meter can generate automatic electrical energy consumption reports, making consumption projections and analyzing the power grid. The meter is able to provide information about RMS voltage and current, average and apparent power, and also the power factor of the place where it is installed. The Smart Power Meter operates in a voltage range of 127 to 220 Volts and minimum current of 0.5 Amperes up to a maximum current of 80 Amperes. The sensors work with a TCP/IP connection over Ethernet network cable and can be configured by web browser.

C. Subsystems

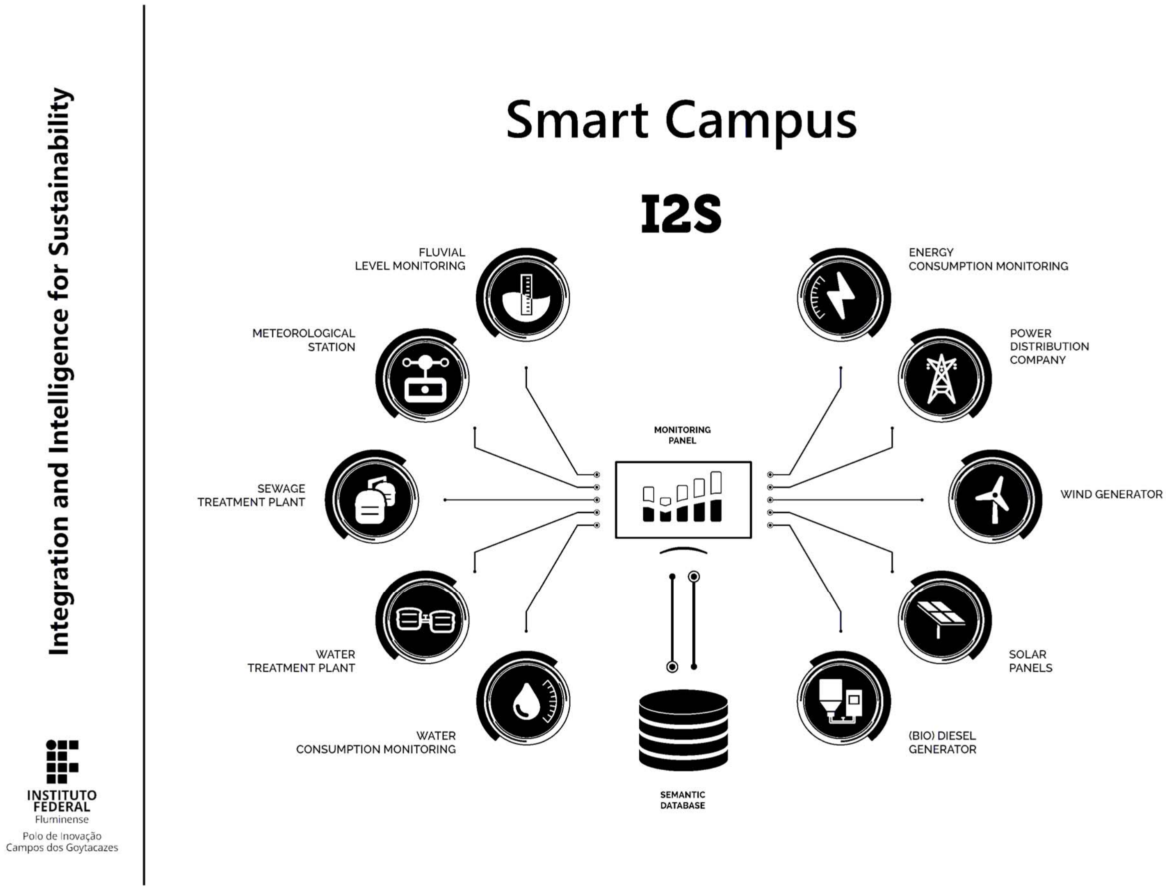
The subsystems have a vital importance for the I2S system, each subsystem is an independent project and will be instrumented and automated according to the researchers working on them, and this is the reason why the system is being designed to accept different types of communication, sensors inputs, etc. On the sections bellow will be presented primarily the features of it subsystem and it functioning. Figure 1 presents all measurement units that will be covered by the I2S system. The Figure 1 exemplifies the concept of the I2S system.

1) Power Supply

As said before, the Power Supply subsystem is compound for renewable and non-renewable sources of electrical energy. One of the power sources of the PICG are the photovoltaic panels recently installed on campus. It has been installed 100 units of the CS6P 255p photovoltaic module from *CanadianSolar*, totalizing 25,5 kWp of photovoltaic potential. It is estimated that the production of the photovoltaic generation system achieve 34,09 MWh per year, providing power to the PICG by an three-phase 127/220 voltage system. Besides the photovoltaic panels system, the campus has also installed three RAZEC 266 vertical axis wind turbines from ENERSUD. The wind turbines work in a wind speed range of 2,5 m/s (SI) to 12 m/s with capacity of generation of 1,5kW each at the maximum speed, totaling the wind generation system 4,5kW, when working at their full capacity. With both systems generating in their full capacity, is expected that the PICG becomes self-sufficient in electrical energy.

While the PICG has not become self-sufficient yet in electrical energy, it still need energy from the Power Distribution Company, that will continue supplying energy to the campus even in the future as a backup power source trough it low voltage grid. Beyond, and also as a backup source of energy, there will have at the PICG the (Bio)Diesel Generator. The (bio)diesel is produced through renewable and less polluting then fossil fuels, for it production can be used vegetal oil, biomass, animal fat, etc.[14]; and will be produced on campus to supply fuel to the Generator be used when the solar panels or wind turbines are unable to provide electrical energy.

Figure 1 - I2S measurement units overview



2) Situational Awareness

The Situational Awareness subsystem will supervise the weather condition to make all users of the campus aware about the weather at any moment. The subsystem will monitor the conditions of the Paraíba do Sul river, that is located next to the campus. The monitoring is primarily important for the wet season, when the campus can provide for the authorities information about the fluvial level of the river, making it possible to make early decisions that can avoid disasters.

Further, the Situational Awareness subsystem will also monitor the weather conditions through a weather station. The weather station used in the project a WS-1090 from Ambient

Weather, it is capable to monitor indoor and outdoor temperature, humidity range, wind speed, air pressure. These data are extremely important, because can be used for future research, once the data will be stored, and for instance, one of the important parameters to monitor is the wind speed, because the wind turbines has a wind speed limitation and if the wind speed is above that limitation, the turbine brakes must be actuated in order to do not damage them.

3) *Water Treatment Plant*

The Water Treatment Plant Subsystem (WTP) will monitor the amount of water collected and the amount of water available for consumption after treatment at the station. The PICG WTP captures the water from the Paraíba do Sul River and treats it by conventional process. This treatment consists of coagulation, flocculation, decantation, filtration and disinfection. Currently, WTP produces 2,500L of drinking water per day, being able to supply water for approximately 60 people, among employees and students attending the PICG.

4) *Resources Consumption Monitoring*

The Resource Monitoring Subsystem will monitor the electricity and water consumption of the PICG. The Subsystem will be divided in two parts, one will be responsible for energy monitoring and the other part responsible for monitoring water consumption. Smart Meters will be installed on campus in places to be defined in order to supervise the amount of resources consumed on campus, allowing the analysis of the consumption of different parts of the PICG isolated and their total consumption.

IV. Conclusion

The concept of the I2S system is not to be just a tool for intelligent campuses, but also be expandable and opened, spreading the concept of process efficiency for neighborhoods, cities, buildings, campuses, etc.

The system proposed will make possible the management of the resources data by acquiring and integrating these information in a single place. The I2S system aim to promote the integration of all subsystems from PICG, by monitoring the Power Supply, Situational Awareness, Water Treatment Plant, Sewage Treatment Plant and Resources Consumption Subsystem with low cost of implementation and operation, expecting to make the Campos dos Goytacazes Innovation Hub more sustainable, promoting on campus an intelligent and efficient ways of consumption. and the usage of renewable sources of energy, making possible the reduction of operation cost, disseminating even more the importance of being environmental friendly, in a moment that the climatic changes is each day more in evidence, allied to a growing concern of the resource shortage

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