International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 02 | Feb 2023 www.irjet.net p-ISSN: 2395-0072

# Automation Enhanced Green Campus Initiative

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***Abstract*—Because of their activities, universities either directly or indirectly harm the environment. Universities should take the required safeguards to reduce these consequences as much as possible. The green campus initiative aims to minimise harmful effects on the environment while also involving students. Sustainability of the environment and infrastructure, climatic and energy adaptation, and waste and water management are all examples of "green campus." This approach uses the "Internet of Things" concept to create a green campus setting. Data is gathered and sent to the admin via sensors placed at specific points in order to automate the campus. Since data are updated often and the appropriate authority is informed to take action, the sensor network will use less energy overall.**

***Keywords:*** ***Internet of Things, ESP32 controller, Mq3 sensor, RFID tags, SWOT analysis, LoRA transmission, nZEB, ArcFace, FaceNet, Key Performance Indicators, LEED, BREEAM***

## I. INTRODUCTION

In order to foster sustainable and eco-friendly practices on campus, a green campus blends environmental friendly measures with educational initiatives. We would like to boost student participation in maintaining a green campus with the help of this platform.

Many of these reforms for a green campus focus on the day-to-day, practical aspects of campus life, such as proper waste disposal, a clean environment, or tree planting.

Before advancing it is important to get a firm grasp about the criteria that qualifies a campus as being green. A green campus cannot be defined only by the various advanced technologies it integrates nor solely on the basis of various methods that it implements.

A green campus should be eco-friendly, unlike traditional campuses, a green campus should reduce the carbon emissions generated, reduce the energy consumption of the campus, have proper waste and resource management.

Traditional buildings lack enhanced automation. Some buildings may be considered to be green by controlling various emissions, but mostly do not incorporate any automation.

Automation is key in today's world. Without automation, each task becomes repetitive. When tasks are made repetitive, it requires a huge amount of labor. For example, to monitor whether a trash can is empty or not a human would have to monitor the trash can continuously or at least once every few hours.

Dedicating time and effort each day to checking whether the trash can is filled or not is a task that is repetitive and one that will cause inaccuracy. The human may not be there to notice the trash can being full at the exact moment. They may arrive a couple hours after. This makes the whole process inaccurate and time-consuming.

Human error is a big reason why many processes are becoming automated. Devices are now able to detect precise readings and send the data to the cloud for interpretation. With the integration of Internet of Things into a green campus, human error can be reduced to nil.

From the previous example, if we we're to integrate an ultrasonic sensor into the trash can, we would not require the assistance or presence of a human. The device would take continuous readings of the length between itself and any obstruction. If the reading is very low, an alert would be sent to the maintenance personnel indicating that the trash can is full and needs to be cleared out.

Automation enhancements will not only reduce human error and increase response time but will also make the campus much more green. Advanced technology used correctly to reduce energy consumption and bring about smart waste management can make a traditional campus transform itself into a green campus.

## II. RELATED WORKS

Jaka Fajar Fatriansyah1., [1] Drones assist in conducting location surveys at the research site to collect research data, such as the number of buildings and the limits of the study area. The campus area, woodland vegetation area, plant or garden vegetation area, and parking area were all calculated using an ArcGIS tool.

Marsudia., [2] Data is collected from the students and the information is discussed among the organising team. They set necessary goals to make the place more greener and sustainable. UI green metrics are used to evaluate the green campus effectiveness. Various methods like SWOT analysis are done to evaluate the work implementation.

Kuo-Hsiung Tsengd., [3] A microcontroller is used to provide the temperature and humidity data in a perception layer of the architecture that they use. Through LoRa transmission, packets are sent from the network layer to the receiving module. The returned data is stored in the database at the application layer, and then the material that needs to be displayed is shown on the monitoring webpage.

Ting Chen., [4] Here they have used wireless technology to implement the smart/ intelligent campus while using the RFID tags. This approach improves communication, security, and allows for system connections to lighting and doorknobs. Creating a seamless student experience. With this lighting conditions in the campus are controlled and energy is saved. Data analysis and optimization is also done to improve campus activities.

Pedro Moura., [5] The study demonstrates how retrofitting existing buildings with the right technology can help achieve the goal of turning them into virtually zero-energy buildings (nZEB) at a reasonable price. They introduced the technology of Internet of Things in order to make the buildings more smart and connected which can then be controlled by the user. IoT devices are installed to control HVAC and to reduce energy consumption by the entire campus.

Radiant Victor Imbar., [6] Uses “Operating by automation" technique to make the campus smart. can resolve conflicts of interest between stakeholders and use public intelligence to add to the system's intelligence.

Summarizes over various frameworks available for the smart campus.

Sunti Sopapradit., [7] Green university policy committees are established which will try to understand energy consumption by viewing past data of the campus. Teams are made and appointed the task to run the campaign. These teams work according to the policies set by the committee. Various steps for preparing the model are analyzed and monitored. Nine experts evaluate the model's appropriateness. The experts use standard deviation and mean to evaluate the effectiveness of the model.

Zhao Yang Dong., [8] In this article, a sentient learning-oriented smart campus is envisioned, described, and articulated with the major objectives of addressing stakeholder interests and attempting to enhance educational performance at the quick speed of technology innovation. The smart campus revolution's multidisciplinary influencing variables are also covered.

Lavanya A., [9] The temperature sensor measures the surroundings and determines the ambient temperature. The cloud platform will then get this data for additional analysis. To save energy, the campus's temperature and lighting are modified based on data transmitted to the cloud platform.

Adulwit Chinapas., [10] Identification cards and face matching are carried out using Dlib, FaceNet, and ArcFace. The face and ID card are both identified, and a matching percentage is calculated by comparing them based on illumination, location of the head, and eyebrows. According to the results of the experimental investigation, the system based on ArcFace produces the best results, with a 99.06% accuracy rate for face detection and a 96.09% accuracy rate for face comparison. ArcFace performs better than previous approaches because it employs MTCNN, straightens the face picture, and restores the locations of the facial components in addition to using MTCNN.

Hassan Abdul Mouti., [11] Utilises cutting-edge technology and equipment to generate energy for houses while conserving. Automation of the home's comfort-enhancing gadgets.

OndĜej PĜibyl., [12] The article discusses a variety of smart campus technologies. Here, the survey has been utilized as a tool to learn about the many demands for the smart campus from students as well as their awareness of the concept. They hope to improve the KPIs by using the surveys.

D. Demiroğlu., [13] Existing buildings can integrate sustainable operations and maintenance using the LEED-EB methodology. A supply-side strategy that reduces energy use on campus has various advantages, including cost savings from lower energy bills and a profitable investment. A green building that conforms with requirements can be created by adhering to the principles.

Esrom Mahlatsi Malatji., [14] The framework in this article is one that is based on key performance indicators (KPIs). Smart people, smart education, and a smart environment are just a few examples of the traits and KPIs of the smart campus. The ultimate objective is to redefine the KPI indicators as the basis for the green campus framework.

Oliver Bates., [15] This work recognises and comprehends the daily requirements of those who reside, work, or attend school on campus. to make the campus infrastructure controlled-accessible so that we can better comprehend and improve the operation of the university's systems. The ultimate objective is to have total control over campus systems to research how IoT affects people.

Hsing-I Wang., [16] In this method, sensors are used to monitor the atmospheric CO2 concentration and turn on air conditioners appropriately to conserve electricity.

Table 1: Table consisting of different approaches used, pros, cons and outcomes gathered in this literature survey.

| S.No | Title | Methodology | Pros/Cons | Year |
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| 1 | [1] Green Campus Design for National Institute of Science and Technology: Implementing UI GreenMetric Criteria to Create Environmentally Friendly and Sustainable Campus | Drones assist in conducting location surveys at the research site to collect research data, such as the number of buildings and the limits of the study area. The campus area, woodland vegetation area, plant or garden vegetation area, and parking area were all calculated using an ArcGIS tool. | PROS<br>They employ formulas to determine the proportion of the forest to the whole area, which can help to raise the score on the UI green measure.<br><br>CONS<br>Only the vegetation is given attention; other areas, such as garbage management, are not. | 2021 |
| 2 | [2] The Green Campus Concept Implementation Based on Environmental and Infrastructure Arrangements: A Case Study of Sports Center Facilities and Infrastructure University of Papua, Indonesia | Data is collected from the students and the information is discussed among the organising team. They set necessary goals to make the place more greener and sustainable. UI green metrics are used to evaluate the green campus effectiveness. Various methods like SWOT analysis are done to evaluate the work implementation. | PROS<br>They are making the change for sustainable development.<br><br>CONS<br>They are using humans to apply changes in the environment. | 2021 |
| 3 | [3] Green Smart Campus Monitoring and Detection Using LoRa | A microcontroller is utilised in this architecture's perception layer to convey the data from the temperature and humidity sensors. Through LoRa transmission, packets are sent from the network layer to the receiving module. The returned data is stored in the database at the application layer, and then the material that needs to be displayed is shown on the monitoring webpage. | PROS<br>To get exact information on temperature and humidity, IoT sensors are employed.<br><br>CONS<br>LoRa is a costly affair. It will require complex architecture and modules for transmission. | 2021 |
| 4 | [4] Smart campus and innovative education based on wireless sensor | Here they have used wireless technology to implement the smart/ intelligent campus while using the RFID tags.<br>This approach improves communication, security, and | PROS<br>The wireless sensors introduction to the smart campus frameworks promises a lot of growth of the campus. | 2021 |

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| | | allows for system connections to lighting and doorknobs. Creating a seamless student experience.<br>Data analysis and optimization is also done to improve campus activities. | CONS<br>The range of the wireless sensors is limited so it takes more funding to implement a wireless network all over the campus. | |
| 5 | [5] IoT Platform for Energy Sustainability in University Campuses | The paper demonstrates how retrofitting outdated structures with the right technology can help achieve the goal of converting such structures into virtually zero-energy buildings (nZEB) at a reasonable price.<br>The installation of IoT devices helps the campus as a whole conserve energy and manage the HVAC system. | PROS<br>low implementation costs<br>Multiple access points should be accessible from the system architecture.<br>CONS<br>It is difficult to integrate new energy and communication systems with the existing infrastructure. | 2021 |
| 6 | [6] Smart Campus Model: A Literature Review | It uses the "Operating by Automation" technique to intelligently equip the campus. can resolve conflicts of interest between stakeholders and use public intelligence to add to the system's intelligence. summarises the many smart campus frameworks that are available. | PROS<br>The control and overall performance of the campus are improved by the implementation of the smart frameworks.<br>CONS<br>It is necessary to have people who are knowledgeable about the frameworks being discussed. | 2020 |
| 7 | [7] Green University Using Cloud Based Internet of Things Model for Energy Saving | The creation of green university policy committees and the analysis of historical data to understand energy consumption are both done. Analyses and monitoring are conducted during various model preparation processes. Nine experts evaluate the appropriateness of the model. | PROS<br>This model analyzes and uses past data for energy saving which will help to build a better and efficient model that has low error and better performance.<br>CONS<br>The models results are checked and evaluated by 9 experts which takes much time and effort. | 2020 |
| 8 | [8] Smart campus: definition, | Here, a human-centered learning-oriented smart campus | PROS | 2020 |

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| | framework,technologies, and services | is envisioned, defined, and framed with the main goals of meeting stakeholder interests and improving educational performance at the speed of technological advancement. Interdisciplinary factors that either support or hinder the smart campus revolution are also discussed. | Proposed HLSC promises the improvement of the campus.<br><br>CONS<br>A smart campus framework may not always be followed as mentioned, sometimes the goals of stakeholders may vary. | |
| 9 | [9] IoT-Enable Green Campus Energy Management System | The temperature sensor measures the surroundings and determines the ambient temperature. The campus's temperature and lighting are then modified using this data, which is subsequently supplied to a cloud platform. | PROS<br>IoT creates a connected world, where everything can be collected automatically without having to have a human present to observe and note down the observation.<br><br>CONS<br>Maintaining both cloud platform and IoT devices takes a lot of resources | 2019 |
| 10 | [10] Personal Verification System Using ID Card and Face Photo | Using Dlib, FaceNet and ArcFace, the id card and facial matching is done.<br>The face and id card are detected and based on eyebrow, head positioning and lighting both are compared and a matching percentage is derived. | PROS<br>According to the results of the experimental investigation, the system based on ArcFace produces the best results, with a 99.06% accuracy rate for face detection and a 96.09% accuracy rate for face comparison.<br><br>CONS<br>Model has to be very intensely trained, to obtain a high accuracy. | 2019 |
| 11 | [11] Smart Innovation Applications for a Greenhouse Using Sustainable and Renewable Energy in the UAE | Uses the latest tech and tools to conserve and at the same time generate energy for the households.<br>Automation of the tools to make the household more comfortable. | PROS<br>The model has the potential to save a lot of energy and move into sustainable living.<br><br>CONS<br>The model may change based on the geographical location in | 2018 |

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| | | | which the technology is implemented. | |
| 12 | [12] Student Perception of Smart Campus: A case study of Czech Republic and Thailand | Various smart campus techniques.<br>Here they have used the survey as a tool to know the various requirements for the smart campus from students and their knowledge towards the smart campus.<br>Using the surveys they want to strengthen the KPIs. | PROS<br>Here their survey proves the efficiency of the smart tech in the campuses.<br><br>CONS<br>The background and the conditions of their campuses and other campuses may differ so the KPIs also differ. | 2018 |
| 13 | [13] Evaluation of the Green Campus Approach on the Campuses in Turkey | Existing buildings can integrate sustainable operations and maintenance using the LEED-EB methodology. A supply-side strategy that reduces energy use on campus has various advantages, including cost savings from lower energy bills and a profitable investment. | PROS<br>Numerous universities in Turkey have adopted Green approaches and have seen many benefits.<br><br>CONS<br>Some development plans require extensive research and proper funding. | 2017 |
| 14 | [14] The Development of a Smart Campus - African Universities Point of View | The framework in this article is one that is based on key performance indicators (KPIs).<br>Smart people, smart education, and a smart environment are some of the KPIs of the smart campus.<br>The ultimate objective is to redefine the KPI indicators as the basis for the green campus framework. | PROS<br>The suggested methodology is ideal for African colleges since they place a strong emphasis on campus performance indices.<br><br>CONS<br>Obtaining data for the KPIs is a difficult stage to complete. | 2017 |
| 15 | [15] Beyond Data in the Smart City: Repurposing Existing Campus IoT | This work recognises and comprehends the daily requirements of those who reside, work, or attend school on campus.<br>to regulate access to the campus infrastructure so that we may better understand and improve the operation of the campus systems. | PROS<br>Making a more interactive green campus community is integral in sustaining the campus.<br><br>CONS<br>Since this is a large, broad project the costs are fairly high and much funding is required. | 2017 |
| 16 | [16] Green Campus Paradigms for | In this method, sensors are used to monitor the atmospheric CO2 | PROS<br>It is possible to | 2017 |

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| | Sustainability Attainment in Higher Education Institutions-A Comparative Study | concentration and turn on air conditioners appropriately to conserve electricity. | effectively administer the computer laboratories. When the temperature reaches a predetermined threshold, the air conditioners won't switch on till then.<br><br>CONS<br>Exact temperature monitoring will be difficult, can only approximate. | |

## III. CONCLUSION

From the above literature survey, we can say that many of the researchers have used various methods to understand, automate and achieve a green campus. A common point that is being relayed on every paper is the integration of technology to make the campus more connected. Various methodologies are also mentioned such as LoRa, ArcGIS, FaceNet, LEED, BREEAM, ArcFace. We can observe that each paper focuses on different aspects such as HVAC control, data transmission rate, green building framework, area mapping, facial matching, humidity control, lighting control. All of the methods have shown a reasonable decrease in energy reduction and increase in overall campus controls. Increasing funding and implementing highly accurate sensors can ensure better results.

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