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Data Warehouse Structure for Energy Monitoring System Towards Campus Sustainability

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ABSTRACT

ICT gadgets are turning out to be increasingly widespread in all parts of human life. ICT devours energy, additionally a significant method for sparing energy. In a university campus, it is not unusual for students to own and use more than one gadgets for personal or academic purpose. Conservatively, it has done as such by making energy using systems performance faster. Taking into contrast the worldwide emphasis of the effect of energy consumption in general, there is a developing focus to the power utilization connected with ICT hardware. This work is designed to calculate energy consumption for ICTs' and to show analyzed reports and charts for top managers. To accomplish the research, the author needs to depend on the methodology that permitted us to address ways in which energy can be calculated. In regard to the research, we proposed a program that will calculate total cost of ICT devices used, show charts and reports and store these devices in the database.

Keywords: *Energy Consumption, Analysis Chart, Monitoring System, Sustainability, Campus Greening*

1. INTRODUCTION

Global warming has become a realistic concern for the inhabitants of planet earth, this phenomenon is defined as the gradually increase of the earth's temperature; this is attributed to the increase in emission of greenhouse gases house gases like carbon dioxide (Co2) into the atmosphere. The Earth's average temperature has warmed by about 0.76°C over the past 100 years, with most of this warming occurring in the past 20 years [1](Greg & Kate 2015). This temperature change might be seen as little and insignificant but little average change in the earth's temperature eventually becomes big changes in the earth's climate and for this temperature change to occur large amount of energy has to be emitted.

A high rate of electrical consumption has been observed in the education infrastructure. This can be attributed to the use of various devices for education and management purposes which consume large amounts of energy and therefore translates into high bills and green house emission as high consumption requires high electrical generation. There are also incidents of Aside from the use of ICT devices, staff and students tend to forget to switch off after use, this kind of attitude consume lot of energy and increases the amount of bill to be paid.

This project is aimed at developing a tool simulator for a middle-sized educational institution, to check the total Information and Communications Technology (ICT) energy consumption usage of the institution to ensure campus sustainability.

The project is being done to analyze research based on energy consumption in the ICT; to select the most effective tools and techniques that will be used in the research; to identify the requirements for creation of application to manage student and staff usage of ICT energy consumption, creation of relevant database that stores ICT device, creation of applications that allow staff to see different types of analyzed reports for energy use and total cost; to design the dimensional model to analysis the application; to design and implement the graphical user interface to fulfil above requirements database; and to test and evaluate the new application to ensure proper working conditions.

2. Energy Consumption in University campuses

The increase in the number of ICT products is directly related to the increase in energy consumption which is equal to the increase in request for energy and also equal to the increase in energy production and with the poor use of clean energy. This results in more emission of greenhouse gases.

Energy consumption can be defined as the conversion of energy from a functioning form into an unworkable usage. Final energy consumption refers to the amount of energy altered during the point of use. Energy consumption covers a wide range of energy sources such as electricity, natural gas, and solar power etc., Energy consumption refers to the final output from these sources of energies. Under this project title energy consumption does not just refer to the energy consumed by the final device but also the energy consumed by supporting systems and devices.

In the case of an IT laboratory in a university with 40 desktop computers these computers also need internet access and this requires routers, switches, hub, bridge, etc.

Therefore: Total Energy Consumed = total energy consumed by devices + total energy consumed by supporting devices.

2.1 Relative Significance of ICT with Regards to Energy Consumption

In contrast to total quantity of energy used by the organization in housing and the transport segments, ICT concluding related energy use does not seem extremely important at a first glance. DG TREN and the business-as-usual (BAU) 2020 projections depend on the baseline scenario of the effect assessment [2].
According to the former, increase in ICT energy use will be at least 400 terawatt hours (TWh), mostly determined by the normal dissemination of larger television screen, higher speed broadband access or higher limit data centers. Since these drivers where mostly housing and halfway industrial, the same distribution was assumed among segments for 2020 and for 2005.

2.1.1 Communication networks

It is essential to have correct and reliable measured data regarding energy consumption in a university campus. If a part of a building is assigned exclusively to other departments, there is a necessity for calculating energy consumption for each department. It goes the same with hostels, where each apartment bill must be calculated separately to identify individual consumption. There is increased interest in data error analysis and developing methods that can point out possible meter malfunction. Also, without correct measured data it is not possible to monitor and prove benefits of applying energy saving measures. It is not possible to identify which building or hostel should consider more measures in conservation. Creating a model of energy use helps in future building planning, it can provide useful information about most probable energy consumption for similar buildings. Also these models can be used to predict energy use in different conditions, show impacts of possible energy savings measures and help in finding optimal way of reducing energy costs [3].

Bart Lannoo [4] discussed that three segments of networks communication were put into consideration: mobile network operator, networks in office, and customer area hardware. Calculation for mobile network operator method used is the same methodology used by Malmodin et al [5].

The bottom-up approach was used to carry out research on electricity use, where the power use of single segments of the network is totalled to calculate the sum total consumption. The approach proposed is top down: The sum total electricity consumption of various telecom suppliers and in light with the digits we gauge the worldwide electricity use in communication networks. The same method was applied by Malmodin et al [5], viewing the information from various telecom administrators, per mobile subscriber minimum electricity use and per fixed subscriber was determined. Multiplication of these values with the overall subscription numbers and summing the outcomes gave them an estimate to the overall electricity consumption in telecom operator networks.

Fixed broadband and fixed telephony distinction between them is made, since there is a trust that the power use for each client of services can differ altogether. Fixed networks to broadband and telephone services is considerably more troublesome in area of electricity use than for mobile fixed case since the two administrations regularly share a physical platform.

2.1.2 Network in offices

In this segment the purpose is to identify the energy consumed by network tools in the university workplace, eliminating network tools in data centers.

A review by Lanzisera et al [6], which assesses the United States of America and their overall power use of information system hardware in the same private structures and workplaces. Studies are carried out on network equipment IP-based, which includes the power consumption used or cooling foundation. Their yearly power use gauge depends on a minimum power usage for every gadget, values for 2008 is used with conjectures until 2012, which is being applied. Equipment for office use is considered in view of choice of the grouping, additionally an expected overhead for cooling is summed. For the overhead to be estimated, an approach which was applied in data centers was used, where the power provisioning hardware and cooling gear consolidated commonly use up energy as much as the IT hardware itself.

2.1.3 Equipment in student and staff hostels

This aspect of research looked on the electricity use of housing network access tools. Every internet subscriber has a network hub or a modem to access the network whether wi-fi, or otherwise.

The percentage of broadband subscriptions (of aggregate web) in Lanzisera et al [6], they refer to the narrowband subscriptions quantity which some students or staff who are not satisfied with university network or cannot access the network in one way or the other.

2.2 Personal computers

Evaluations were based on the quantity of PCs being used in the campus. These numbers incorporate desktops and portable PCs, however, terminals associated with the centralized server and gadgets, for example, advanced cells or tablets that have just a few, yet not all, of the elements of a PC (e.g. they may not have a full-sized keyboard, a vast screen).

The overall energy consumption is being calculated by multiplying the average energy consumption figures per device by number of devices. Distinguishing between household and office desktops and laptops, and CRT and LCD (liquid crystal display) was made.

2.3 Number of PCs

Based on presumptions, an estimate for the total number of personal computers in use per region and worldwide for 2000-2006 was carried out. As of 2007 onwards, there is insufficient information accessible in the UN database to make a dependable gauge. Be that as it may, annual PC deals numbers are accessible for 1991-2010. If the lifetime distribution of PCs is known, we can utilize these sales information to decide the quantity of PCs being used in 2007-2010.

2.4 Laptops and desktops, household and office computers

It is said that laptops consume less energy than desktops. Therefore, there is a need to know the quantity of portable workstations and desktops that are being used. This can be taken from the yearly deals data for portable workstations and desktops and the lifetime model of PCs we decided in the previous segment. The share of portable workstations has essentially expanded in the previous five years, from around 32% of set up base of PCs in 2007 to 54% in 2012.

A peculiarity is made between PCs that are being used in an office surrounding and PCs that are used in households, since the patterns usage in these surroundings contrast. In a review on the

2.5 Data Centers

In 2012, to evaluate the sum total of electricity used by data centers worldwide, this was based on the most recent review by Koomey [7]. It gives an assessment of data center electricity use for 2010. In any case, there are two principle contrasts: (a) incorporate orphaned servers and (b) Information from spec.org was investigated which demonstrated a potential failure of power use for each server for the time in 2008-2012. The data center power use is computed as: in other to get the overall power use of servers we multiple, for each of three server classes, the average power per server by the quantity of servers around the world. It is then included that the power used by capacity hardware (tapes and hard plates), communication gear, (for example, network switches) and infrastructure hardware, (for example, cooling and power provisioning misfortunes) by applying three overhead variables. The quantity of servers worldwide is balanced upwards with a variable 1.25 to represent orphaned servers, i.e., around 20% of the servers in data centers are utilizing power but not delivering computing services. The framework overhead (PUE) is a component ≥1 we apply to the past final products. For 2012, we guessed a 5% change on the 2010 upper bound estimation of 1.92, given the expanded focus on energy proficiency, which brings about a PUE = 1.82.

2.6 External Monitor

The screens incorporated in portable workstations are considered in the power utilization of tablets. However, despite everything to consider for external displays, connected to most desktops and a few portable PCs. In Bart Lannoo's [5](2011) review it shows that 96% of desktops and 26% of portable PCs in USA family units were associated with an outside show in 2010.

2.7 Analysis and Review of Related Research

Various research have been made into ICT‘s role as a contributor to global warming, one of such research can be seen in Seai [8]. The research in Seai [8] based on Seai's ICT Working Group for the Public Sector on their calculation for desktop PC, is by assessing how much it cost to run the equipment.

A standard desktop PC and a 17" LCD monitor use up to 70-150 watts per hour and a single desktop PC which is powered on for at least an average of nine hours per working day can use up to: 150 watts*45 hours=6750 watts per desktop per working week [8]. While Seai [8] based his calculation on just PC, Green Digital Charter [9] talks about the seven guide approach to measuring carbon foot print of ICT. It should be seen as an iterative process and will help identify where there is gap and how the process can be refined. They also based their calculation on; Resource, Number of ICT gadgets, Uptime (hours), Standby (hours), Downtime (hours), Consumption (kWh), CO2 emissions (kgCO2e), Total Cost (favored currency). Ascertaining energy utilization of ICT gadgets can be either evaluated as a rough figure or measured in light of the assets accessible to the environment (Green Digital Charter, 2015). The author will be implementing this standard measurement of Green Digital Charter in the proposed system.

3. Results

A system was designed and developed to compute for the energy consumption of university institution integrated with an Oracle database and Apex application features as basis for the data warehouse. An online survey was carried out to get the user requirements, in which the total number of people who answered was 40. The results of the requirements gathering was used in the design of interface and in other required functions of the system. The system was implemented with the requirements in mind.

Figures 1 to 4 shows the interfaces of the implemented system.

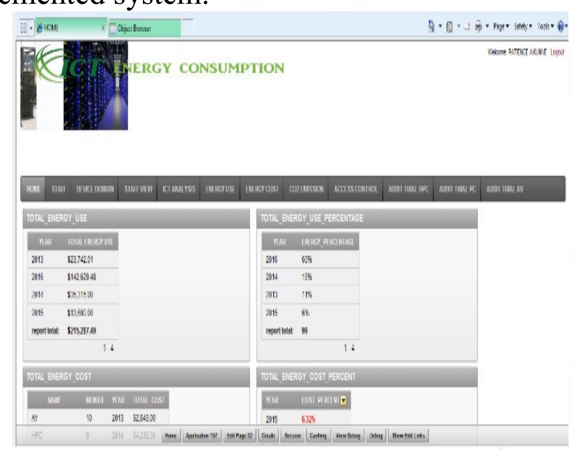

Figure 1: Homepage

Finally, the system was tested as the final objective was achieved, the system was tested to verify the security level, and to make sure every function was covered. The test verified the fact that the system functioned perfectly.

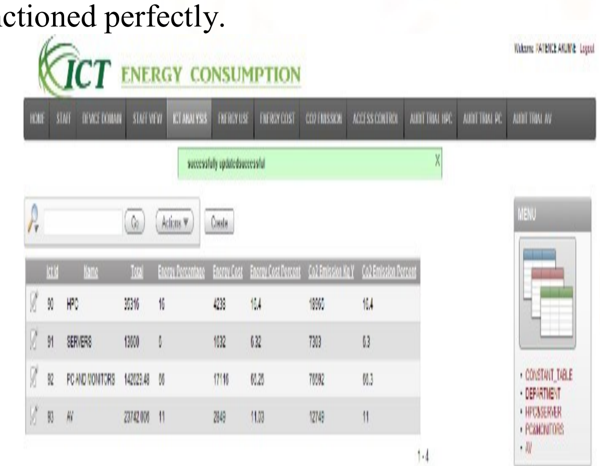

Figure 2: ICT Analysis

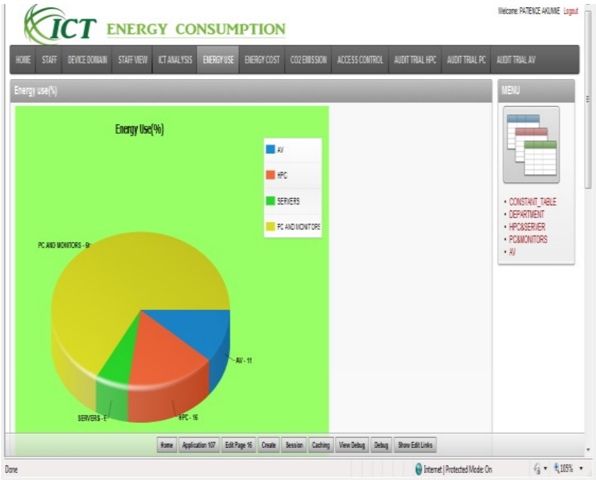

Figure 3: Analysis of Energy Consumption

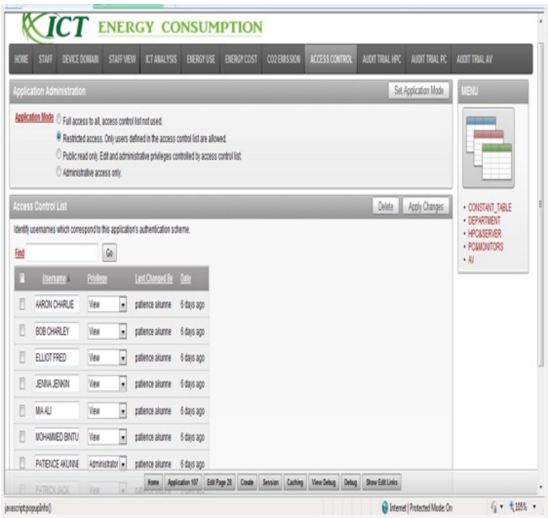

Figure 4: Access Control

4. Conclusion

The research is a development of a data warehouse structure leading to the development of an ICT Energy Consumption Calculation System development for an educational institution. This system will be useful and it will enable them to be conscious about their excessive use of energy which will lead to policies regarding campus sustainability.

There are some future enhancements that can improve the quality of the system. These functions could not be implemented because of some setbacks. Additional features of this system that can be implemented in the future include: system should be able to print out report; calculations can be done based on departments to know total energy consumed by those departments; system should be able to send out emails; design the system in a way it will help reduce the energy consumption. E.g. by embedding a sensor to the system which will help detect when the energy is high and can reduce it.

5. Recommendations

Although the system is usable and easy to operate and understand by users of different age groups, it is recommended for developers to provide a user manual of the system in other to enhance users' knowledge on the system. It is also recommended that the system's vulnerability is tested by professional software testers and possible hackers.

6. Acknowledgement

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