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Optimisation of Energy Efficiency in MU Buildings using WSAN

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Abstract Oil and gas remain the largest sources of the primary energy used for the production of electricity in KSA. Based on data published in [1], 57% of electricity generation comes from oil and 43% come from gas. These main two resources give total installed power generation capacity about 45000 MW. The consumption of energy (per capita electricity consumption) increases day by day due to different factors like increasing use of energy intensive appliances such as air conditions and ovens and subsidised tariffs. Subsidising the electricity tariffs is also a factor for the intensive use of electricity in the domestic and industrial sectors. The governmental buildings consume about 11% of the total national energy consumption, and 60% of this percentage is lost due to the misuse of the light and air conditions [14]. This loss could be reduced by using a smart system that monitor and control operation of light and air conditions in all administrative buildings. Smart light, smart window, and motion sensors, etc. can be used to increase the energy efficiency of the administrative buildings. Optimisation of energy efficiency in Majmaah University (MU) administrative buildings using a wireless sensor and actuator network (WSAN) is an efficient method for managing the power consumption.

***Index Terms*—Energy Efficiency, WSAN, Optimisation, Majmaah University**

I. INTRODUCTION

THe technological innovation has increased swiftly since the beginning of the 21st century, which leads to improving the standard of living. In particular; wireless communication is regarded as one of the most critical technologies that even changed our way of life [10].
This research proposes a framework for optimising the energy consumption in the selected buildings by modelling all the disturbance parameters the building dynamics. Then the optimisation problem will be solved to benchmark its performance on a numerical study. Therefore, an energy management system will be used to suggest or execute energy saving procedures.
WSN actively takes good advantages from the wireless technology by building a comprehensive tent work that needs no any wires and can be implemented in any desirable locations [11]. Moreover, SWN can be applied to the wireless sensor and actuator networks (WSANs) and Wireless personal area networks (WPAN) which are the most critical applications in the modern life [12]. Participate in the transition toward the smart public infrastructure as well as other technologies, such as agricultural and industrial.
The green and sustainable economy for the human being future can be claimed that it depends on the Smart WSAN (SWSAN) because it develops various infrastructures, production processes, and services [13].
Achieving green and sustainable economy are regarded as the most desired aim for any country in this world. In fact, in the developed countries, the investment in these technologies is growing up rapidly to achieve the emerging requirements for reduced and more responsive power consumption with a relatively low-cost investment in "greening"[13].
Indeed, many of the industries/public services providers are still quiet to adopt wireless within their systems/production processes. As it is their impression that WSANs are not dependable (i.e., their availability, reliability, maintainability and maintenance support performance are not at the satisfactory level), and no critical system operation should depend on it [15].
As mentioned in [6], Wireless sensor and actor networks

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(WSANs) can be defined as a group of sensors and actors grouped together by wireless medium to perform distributed sensing and acting tasks.
In [7], for improving the energy efficiency, the building management systems (BMS) is used based on WSAN. The algorithm proposed in this work required dynamically arranging transmissions from sensor nodes without the need for synchronisation. However, this method suffers from instability and needs more control options.
Today, organisations use IEEE802.15.4 and ZigBee to deliver efficient solutions for a variety of areas including consumer electronic device control, energy management and efficiency home and commercial building automation as well as industrial plant management [8].
The use of traditional technology: Wireless Sensor Network (WSN) technology is an efficient way to control and monitor energy consumption and to measure the energy efficiency. [9].
In [14], Farajallah Alrashed, Muhammad Asif showed The Residential buildings are investigated for some of the important features related to the residential energy consumption. The work is based on an analysis of the monthly electricity for several buildings. In this work, the WSAN is not implemented. The work has an interesting statistics about energy consumption in KSA. In our research, the day consumption will be considered using WSAN.

II. THE RESEARCH METHODOLOGY

An energy performance model (cafeteria) for assessing various energy conservation measures pertinent to the building envelope and HVAC system design. The collected data required for setting up the model were gathered through simple energy audits [16]. In this model, the WSAN is not implemented.
Based on the literature review, two comments can be highlighted:
1- The energy consumption and efficiency is an important direction and still needs more studies and analysis.
2- Techniques, technologies, and models used in KSA require more research mainly using WSAN

The methodology will consist of:
Literature survey to identify most efficient sensing and communication technologies;
Laboratory design of the energy monitoring platform;
Laboratory testing of the developed solutions, their robustness and effectiveness deployment on two different sites.
Surveys of the sites and periodic interviews with the residents after each intervention

- Development of the data repository at MU for collecting and processing the data
- Development of data analytics for identifying main usage patterns and primary consumers
- Development of feedback mechanisms based on the collected quantitative and qualitative data
- Assessing the value of the feedback and smart control functionality via energy behaviour change.

The methods of implementation and rationale for such methodology is based on the targeted sector. Accordingly, there is now one area which considered as a governmental sector.
The official sector (MU) consists of two separated university buildings with the various functions in each building. The first building in this area consists of the university's administration, managerial offices and the College of Engineering. More accurate statistical data will be provided for each building including rooms, labs and offices based on the fund.

III. PROBLEM FORMULATION

Since 2004, the oil and gas consumptions are experienced rapid growth in the Kingdom of Saudi Arabia. The consumption increased at the period from 2004 until 2014 of 198.7% with annual rate pf 19.9% [2]. Due to increasing of the populations and industry, the consumption of oil is to be increased by 50% in 2020.

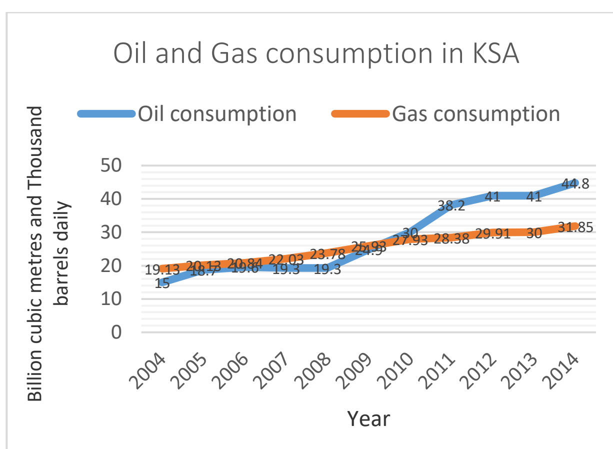

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Figure 1: BP Statistical Review ofWorld Energy June 2015 [11]

Several factors play a significant role in increasing the growth in electricity consumption that cab summarised as follows [3,4,5]:

1- Urbanisation, subsidised tariffs and greater use of energy intensive appliances.

2- The growth of energy consumption by residential sector (more than 50% of the total national electricity consumption)

3- The inefficient use of power which in turn is associated with extremely subsidised tariffs as also highlighted by Alyousef and Stevens [5].

Based on the statistics represented in work [14], 11% of electricity is consuming by the governmental sector as shown in the figure below [4]:

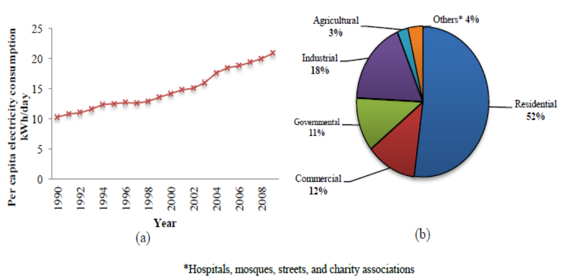

Figure 2: Per capita electricity consumption in Saudi Arabia (a); Electricity consumption by sector (b) [4]

Maybe the electricity consumption by residential sector is high comparing to the governmental sector; but the minimization the power consumption by governmental sector by 25% will lead ti=o save energy 0.55 Per capita electricity consumption kWh, day.

The Energy consumption per million population in KSA comparing to Middle East region is shown in figure 3.

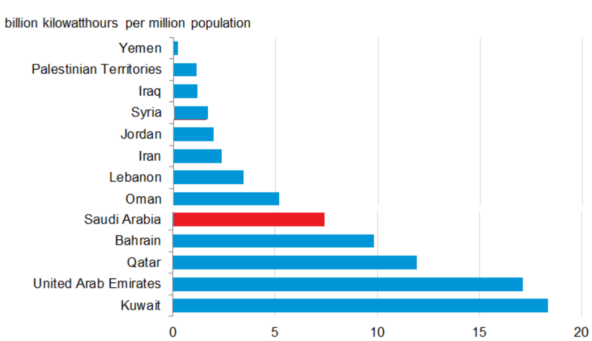

Figure 3: Energy consumption per million populations in MEC.

The primary task this article tackle is to build a suite of data analytics methods that is capable of analysing the monitored data to control and manage the power consumption efficiently.

The proposal brings a high degree of:

Innovation, since modelling user behaviour and providing practical personalised energy management solutions is challenging research topic not well explored yet.

Replicability, since the platform and proposed techniques, could be applied across the country, and to different sectors, including hotels, schools, hospitals, shopping centres, etc. The last WP will look into replicability and adaptation of the system to various areas;

Best use of locally available resources: The work aims at design energy retrofit and saving advice based on the locally available renewable resources.

IV. IMPLEMENTATION AND RESULTS

The needed hardware per single unit (a flat, a lab or an office in a sector) could consist of the following Monitoring equipment: total for one single unit

TABLE I
MONITORING EQUIPMENT

2 Pack Appliance Monitors
Single Appliance Monitor
Base Pack (Display, Transmitter, Data Cable)
Home Energy Management Platform
Vera 3 (Includes WiFi Interface, 4 LAN ports, 2 USB ports, more RAM 128MB)
RFXCOM 433 MHz Interface
Z-Wave USB
Raspberry Pi
Environmental Sensors
TEMPERATURE AND HUMIDITY (THGR810)
Z-Wave Presence Detector (HSP02)

The main steps to implement the research are:

Step 1: The energy management network; installing the electric current consumption monitoring devices, connect the control devices with the primary servers to gather and manipulate the data of the consummated electrical energy.

Step 2: The data gathering of the collected the data of the consummated electric energy through the whole day. Moreover, the collected data is analysed to find out the optimum consumption plan to be deployed in the next stage for the entire targeted project network.

This research focuses on comparing the power consumption according to recommended actions with the

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consummated power in the usual case, i.e. without SWSAN network for data gathering. The saving percentage of the consummated power directly regarded as the scale to evaluate the research successfulness.

As mentioned before, the air conditioners are the primary sources of power consuming. So the power efficiency of air conditioners from the manufacturer are analysed:

The following table is showing the power efficiency of different air conditioners from various manufacturers. Also, the time scheduling to save energy consumed by air conditions will be proposed to minimise cost and difficult maintaining works.

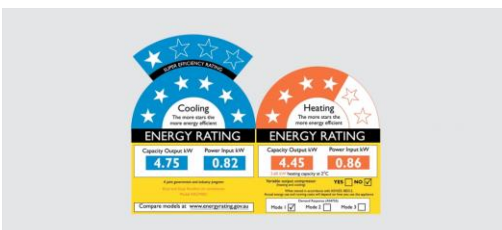

Figure 4: Energy rating of Air Conditioner Labels [18].

There are two main types of air conditioning products on the market [18]: refrigerative products (using the vapour compression cycle) and evaporative products.

There several parameters that should be considered before proposing the suitable air conditioners [18]

Many different elements within your home will impact on the size air conditioner you'll require. These include:

- A heat/cool a single or multiple rooms ;
- Size of room ;
- Wall materialsthat made from;
- Insulation levels; and number of .

Energy classification of A/C units in a particular power class (A, B, C, etc.) also necessary to show the power consumption indication [19].

TABLE II
TARGET STANDARD VALUE OF AIR CONDITIONER

Category	Unit Form	Cooling Capacity	Dimension Type of Indoor Unit	Top Runner Value (APF)	Improved Efficiency (%)	Target Standard Value (APF)
A	Air conditioners of wall-hung type among the non-duct types (excluding multi-type air conditioners that control operation of indoor unit separately)	3.2kW or lower	Dimension-defined type	5.65	3.0	5.8
B			Free–dimension type	6.40	4.0	6.6
C		Over 3.2kW, 4.0kW or lower	Dimension-defined type	4.80	3.0	4.9
D			Free–dimension type	5.80	4.0	6.0

Other sensors measured the power consumption of Lights, electrical technologies (Personal PC with peripherals), air ventilation system.

The consumption of power for the different device based on the percentage of energy consuming for one office are listed in the table below:

TABLE III
TARGET STANDARD VALUE OF AIR CONDITIONER

Type	Air Conditioner	room light	WC light	PC and peripherals
Power (%)	60%	17%	9%	14%

Standard notes for the used device:

1- Air conditioners are old with very low energy efficiency (Most of them class C or above)

2- Lamps used in the office are of the Neon type with 22 Watts and Fluorescent in WC.

Comparing to LED current technology with 3 Watts consumed, Neon consuming about seven times. Table IV show watts analysis for LED, Neon and Fluorescent [20]

TABLE IV
LAMPS POWER CONSUMPTION ANALYSIS

Light Source	LED	Neon	Fluorescent
Watts Consumed	8.00	100.00	160.00
12 hours/day	96	1200	1920
365 days/year	35,040	438,000	700,800
1000 Watts(1 kW)	34.04	438.00	700.80
Cost/kWh	$0.10	$0.10	$0.10
Total Energy Cost/Year	$3.50	$43.80	$70.08

The effect of energy consuming of PCs is not significant. So it will not be considered in energy efficiency plan.

To be clear, we have three approaches to make the energy efficiency plan more efficient, applicable and reliable:

1- To put a time-schedule plan fro saving through using switches on/off the system using smart technologies based on times and motion detectors.

2- to replace old air conditioners with new more economics (Less energy consuming)and using the approach one in parallel and this will give excellent effect but the initial; cost will be compensated by time. The energy saving results will not be noticed at an instant time.

3- To use renewable energy system for power sources. This approach needs more cost and specific infrastructure.

In the second phase, Corridors and services, rooms will

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be considered in the analysis.

1- The first approach is implemented by putting a general electronic switch connected to a motion detector to turn off the main switch.

The conditioner is calibrated, maintained and set to a mean temperature $(22\text{-}25)^0$.

The SWSAN was helpful in sensing, monitoring ad collecting data. Increasing number of sensors (nodes) will be considered in the second phase that will be reflected in using complex energy efficiency plan.

The following figure shows the energy consumption before and after energy efficiency plan.

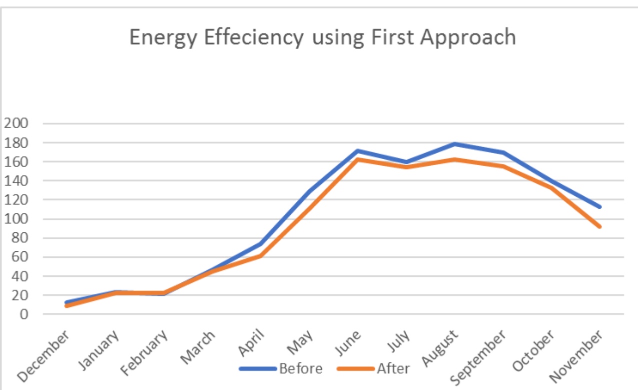

Figure 5: Energy efficiency plan of the first approach

The saving percentages and the average is shown in Table V

TABLE V
Energy efficiency plan of the first approach

Month	Percentage (%)
December	25
January	4.347826087
February	-4.761904762
March	4.255319149
April	17.56756757
May	13.95348837
June	5.263157895
July	3.75
August	9.497206704
September	8.823529412
October	5
November	18.5840708
The average percentages of energy saving	9.273355102

If we know that for the government, the price of kWh is 0.32 SR and the saved power is power 111 kW for one room, then the total money saved is 35.52. For the main building with about 400 places, the total saved money is 14,208 SR (3789 US$) per year.

If a motion detectors price will be considered, 3 US$ (11.25 SR), then the real saved money is 9708 SR (2568 US$)

V. CONCLUSION

Optimisation of energy efficiency in Majmaah University (MU) administrative buildings using a wireless sensor and actuator network (WSAN) is an efficient method for managing the power consumption.

Results of monitoring and saving plan were valid for the first approach.

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REFERENCES

[1] Reggae, Country Energy Profile: Saudi Arabia - Clean Energy Information Portal, http://www.reegle.info/countries/saudi-arabia-energy-profile/SA, [Accessed: 08-Jul-2013]
[2] BP Statistical Review of World Energy June 2015. https://www.bp.com/
[3] Obaid, R. R. and Mufti, A. H., Present State, Challenges, and Future of Power Generation in Saudi Arabia, IEEE Energy 2030 Conference, 2008, pp 1-6.
[4] Ministry of Water and Electricity, Electricity: Growth and Development in the Kingdom of Saudi Arabia, Riyadh, 2009.
[5] Alyousef, Y. and Stevens, P., The cost of Domestic Energy prices to Saudi Arabia, Energy Policy, Vol. 39, No. 11, pp 6900-6905, 2011, http://dx.doi.org/10.1016/j.enpol.2011.08.025
[6] Ian F. Akyildiz Author Vitae, Ismail H. Kasimoglu," Wireless sensor and actor☆ networks: research challenges ☆☆", Ad Hoc Networks, Volume 2, Issue 4, October 2004, Pages 351–367.
[7] D. De Guglielmo, "Wireless sensor and actuator networks for energy efficiency in buildings", IEEE Conference Publications, Sustainable Internet and ICT for Sustainability (SustainIT), 2012.
[8] D. M. Han; J. H. Lim, "Design and implementation of smart home energy management systems based on ZigBee."
[9] IEEE Transactions on Consumer Electronics (Volume:56, Issue: 3),2010
[10] M. I. M. Rawi; N. I. Ramli, "Enabling intelligent wireless sensor networks for passive house", Wireless Sensors (ICWiSE), 2014 IEEE Conference.
[11] Chris Joseph, Demand Media, How Wireless Communication Changed the World, http://smallbusiness.chron.com/wireless-communication-changed-world-33596.html

[12] Ian F. Akyildiz *, Tommaso Melodia, Kaushik R. Chowdhury, “A survey on wireless multimedia sensor networks”, www.elsevier.com/locate/comnet 2006 Elsevier.
[13] Paulo Neves, Michal Stachyra, Joel Rodrigues, “Application of Wireless Sensor Networks to Healthcare Promotion”, Next Generation Networks and Applications Group, 2008
[14] Report by a Panel of Experts, “The Transition to a Green Economy: Benefits, Challenges, and Risks from a Sustainable Development Perspective”, Second Preparatory Committee Meeting for United Nations Conference on Sustainable Development.
[15] Farajallah Alrashed, Muhammad Asif.” Trends in Residential Energy Consumption in Saudi Arabia with Particular Reference to the Eastern Province”, Journal of Sustainable Development of Energy, Water, and Environment Systems, Volume 2, Issue 4, pp 376-387, 2014
[16] Richard T. Watson, “Information Systems”, University of Georgia, 2007
[17] Mohammed M. A. and Budaiwi, I. M., Strategies for Reducing Energy Consumption in a Student Cafeteria in a Hot-humid Climate: A Case Study, Journal os Sustainable Development of Energy, Water and Environment Systems, Vol. 1, No. 1, pp 14-26, 2013, http://dx.doi.org/10.13044/j.sdewes.2013.01.0002.
[18] http://www.energyrating.gov.au/products/space-heating-and-cooling/air-conditioners
[19] Summary Report by Air Conditioner Evaluation Standard Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee on Natural Resources and Energy. https://www.eccj.or.jp/top_runner/pdf/tr_air_con_06.pdf
[20] http://www.teledynelighting.com/pdf/signage/LedvsNeonComparisonChart.PDF