RESEARCH ARTICLE

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Optimized Energy Utilization and Performance Evaluation of an Oil Filling Station in Dubai

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Abstract: This study focuses on the optimized energy conservation in commercial infrastructure and filling station in Dubai without affecting its function and the customers. This method involves the installation of automatic thermostats, dynamic lighting controls and solar panels. The proposed technique covers the HVAC system and lighting system of the infrastructure which need considerable amount of investment which can give full returns in 4 year of performance, and energy conservation is guaranteed in 6 years. The corresponding design and result analysis are clearly discussed in this article and the energy comparison study has proved the effectiveness of the proposed techniques.

Keywords: Energy conservation, thermostat, NEST, dynamic control system, Grid PV.

1. Introduction

In the modernised era of advanced technologies, energy optimisation is a major goal in most of the installations. To attain better economic progress and to sustain the available energy sources, energy saving is important. Balance between the generated energy and the spent energy determines the economic value and the sustainability of a system. Hence, the current work focuses on the need for energy control and sustainability in the commercial infrastructure.

An infrastructure is categorised green only when the energy utilization is optimised so as to conserve conventional energy resources. Hence, a conventional designing of the old building are being done to optimize the energy consumed. Conservation of energy and the efficient use of the same are very important since non-conventional sources are limited. In the past five decades the use of energy for commercial purposes has increased fourfold. In the past three decades alone the rate of increased energy usage accounts for 66% [1]. Also, the rate of carbon emission from energy production has increased up to 51%, which is considered one of the reasons for global warming. Hence, there is an increasing demand to find alternative energy sources and new designs of commercial infrastructure so as to reduce the greenhouse gas emission and utilize the available energy in an efficient manner [2].

The enhanced design of the commercial infrastructure includes the periodical measurement of the amount of energy utilized to analyse the performance behaviour of the building design. Though many advancements are made in the measuring system this remains as an unsolved puzzle in many cases. The ratio between the energy availed and that utilized, determined in the calculation of the building performance, is still not clearly understood by all. To solve these issues CAD issued in the simulation of the energy assessments, and regular energy audits are done. These proposals are accepted worldwide for the accomplishment of a perfect green building design [3-5].

Commercial buildings are indicative of a country's economic development. The productivity of the commercial unit lies in the ambience of the infrastructure. Hence lighting plays an important role in creating a good ambience. Apart from lighting many other sources like air condition and other electrical equipment are also important. When these systems are correctly designed, apart from giving sophistication, they also conserve significant amount of energy. For this purpose, the building performance analysis estimation is required which involves the collection of the past behaviour of the infrastructure. This provides a reliable solution to control the excess use of energy without disturbing the sophistication of the building. The current study deals with the conservation of energy with new substitution methodologies in a commercial infrastructure and presented as a case study. The building under consideration is afilling station in Dubai, ENOC 1079.

2. Basic Facility Details

The current study aims at energy conservation through multiple alternative techniques which are implemented and tested in different commercial infrastructure like ENOC 1079,1083 and 1097. These are all filling stations in Dubai. This study is an extended work of the installation of the lightning systems in the filling station to achieve better energy conservation plans. Several other techniques are going to be implemented with the lightning system so as to conserve more energy. The breakdown on the amount of energy used in the ENOC 1083 is given in Fig.1.

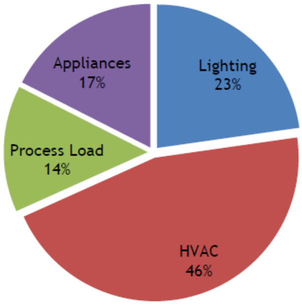

Fig.1. Energy Consumption Breakdown In ENOC 1083

From the chart it is evident that the HVAC system consumes more energy next to the lighting system. The other appliances and the process load share an equal and significant amount of consumption. Hence, the primary fix to be applied is the achievement of the energy balance between various resources. The percentage breakdown is an estimation derived from the annual consumption of the energy by the filling station in kWh units. This analysis gives an equal and balanced allocation of the energy for each system without any deprivation in the calculation. Hence, a prioritization technique is implemented in the estimation methodology. The new design of the infrastructure replaces the traditional lighting system with the use of LEDs. A similar breakdown chart for the filling station ENOC 1079 is given in the Fig.2. In this station the lightning system occupies a major portion implying that it is a major consumer.

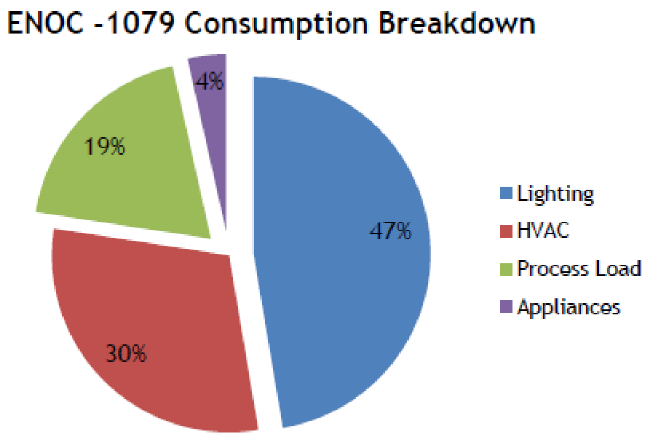

Fig. 2. Energy Consumption Breakdown In ENOC 1079

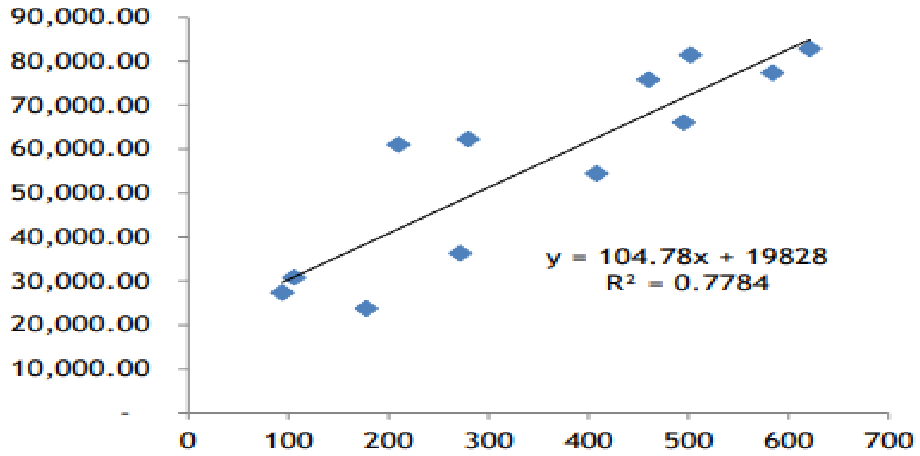

Fig.3. Monthly consumption trend of ENOC 1079

3. Detailed Analysis of Monthly Consumption

The monthly consumption of the ENOC 1079 is given in Fig.3. From the figure it is clear that the usage of energy is higher in the months of June, July, September and October. In the ENOC 1079 the lightning systems consumes more energy. The base load of about 55000kWh was constant throughout the year, and the weather-dependent load of about 25000kWh was consumed during the above mentioned months.

A similar monthly consumption chart for ENOC 1083 is given in the Fig.4.

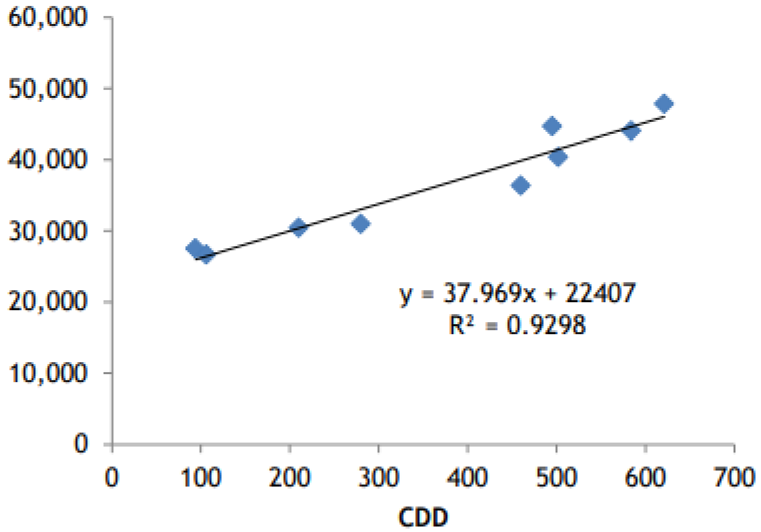

Fig.4. Monthly consumption trend of ENOC 1083

As major quantity of power in this filling station is consumed by the HVAC system and the base load is at minimum constant for about 28000kWh. But the seasonal variable load is maximum up to 75000kWh during the months of winter. Thus, about 63% of the power is considered as the base load and 37% the variable load. The determination coefficient is calculated to be high about 0.924. Thus the power consumption is strongly dependent on the prevailing weather condition.

Both the stations have individual design considerations and use different technologies. Hence, a benchmark index is used to compare the energy efficiency of each station. The exterior BMI for ENOC 1079 and ENOC 1083 was estimated to be 152kWh/m^2 and 79kWh/m^2 respectively. The consideration made during the estimation was that both the station have different number of facilities and service providers. ENOC 1079 was busier than the ENOC 1083 depending upon the number of cars serviced. ENOC 1083 has redesigned infrastructure with modified lightings. The energy consumption graph of both the station for the year 2016 is shown in Fig.5.

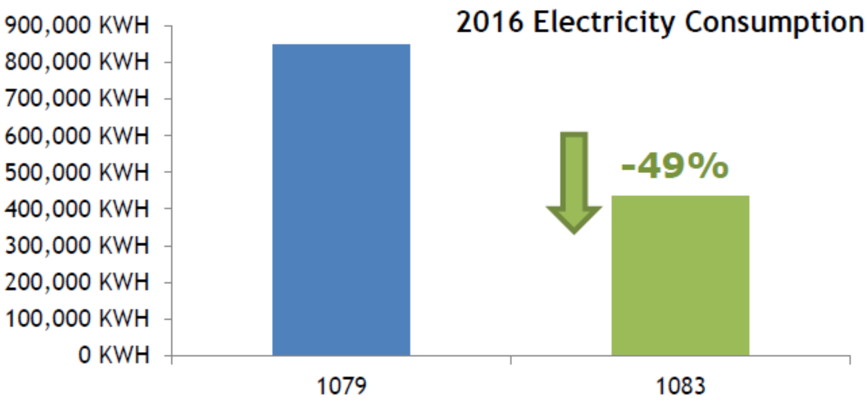

Fig.5. Energy consumption comparison

From the graph it is clear that ENOC 1083 can conserve 50% of power when compared with the ENOC 1079.

4. Proposed Stratergies for the Conservation of Energy

The conservation of energy is done by fixing the issues and replacing high energy consuming devices identified through the energy audits. Energy audit is carried out by a group of professional auditors, and their findings are listed below. According to the audit report ENOC 1083 is a continuous working unit. Also the VRF system and the Air conditioning system used are of high efficiency. The lighting system are turned ON or OFF manually by the employees. Hence, a thermostat is installed to control the energy supplied to the VRF and AC. The ON/OFF of the LED lights is done through sensors so as to turn off the lights during parallel lighting hours. Also, in order to save more energy, the installation of the renewable source of energy unit is recommended in this filling station. In the ENOC 1079 HVAC system was found to be working round the clock consuming more energy. Hence to actualize the amount of energy used by the HVAC system automatic thermostats are installed and the maximum point of 22°C is set. During winter the point is locked at 26°C.

5. Design and Result Analysis

5.1 Hvac Control Thermostats

NEST Thermostats are used for the automatic control of the ENOC 1079. These are simple in design and easy to fix. During different weather conditions the thermostat senses the temperature range and decides by itself the optimum point to be fixed through the AI algorithm. These thermostats have occupancy sensors to find the presence of human movement in the room and turn off the HVAC system when there is zero occupancy. These sensors transmit signal through wireless network. The monitoring and the control of the thermostats can be easily done by remote control. Also this system provides alarm during the overridden system setting conditions. The thermostats installed in the ENOC 1079 are shown in Fig.6.

Fig.6. Automatic thermostats installed in ENOC 1079

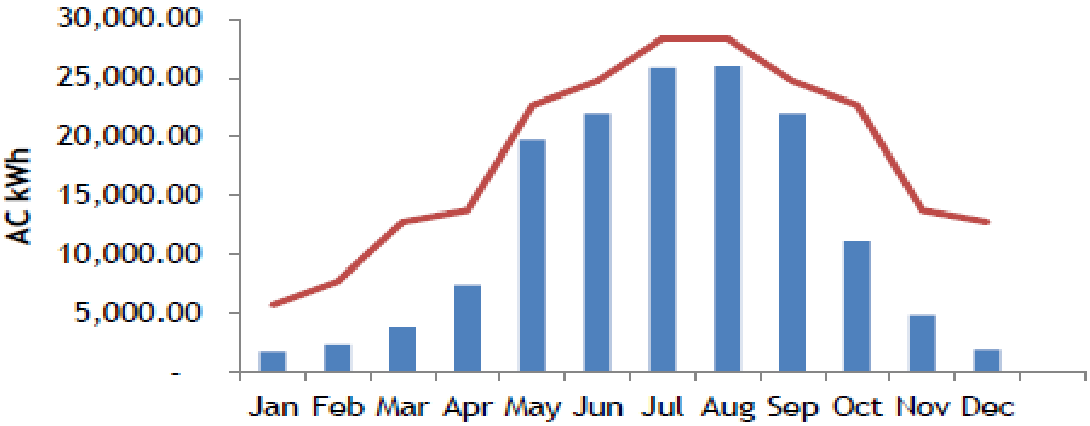

Fig.7. Thermostat energy consumption graph.

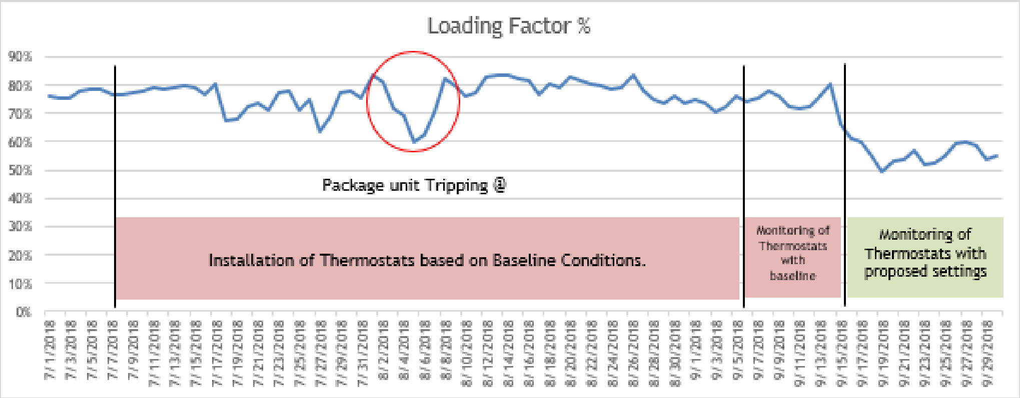

Fig.8. Baseline Values comparison with Metered Data Observation for Thermostat.

Fig.9. Dash Board HVAC System.

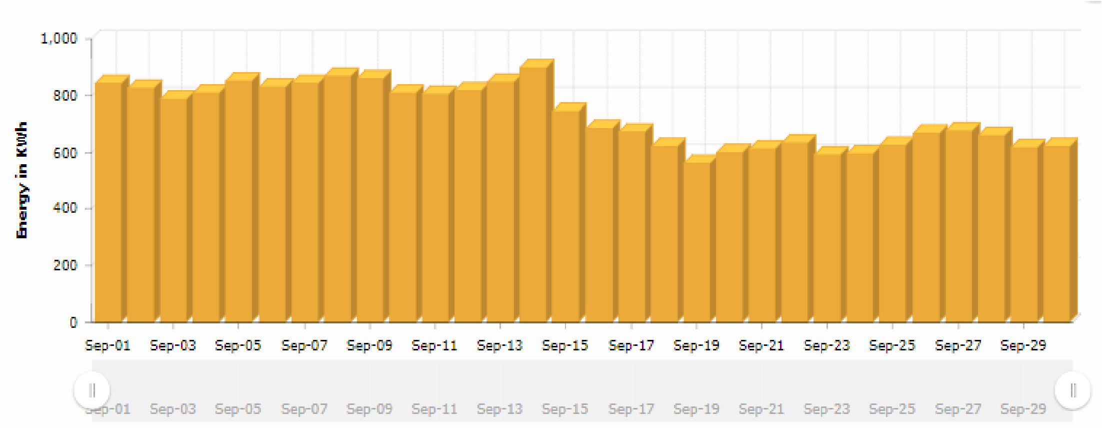

Fig. 10. Potential saving graph of thermostat unit

From the graph it is evident that the automatic thermostat helps in saving about 32% of the total energy consumed by the HVAC system. The overall consumption of the energy throughout a year is reduced by 4.5% which accounts for about 15% energy conservation through the HVAC systems alone by conserving38,300kWh energy.

5.2 Dynamic Light Management System

This system was installed along with the wireless sensors to dim the lights automatically based on the prevailing lighting in the building. These control systems sensethe amount of luminosity necessary for the room and calculate the amount of luminosity present in the room. According to that the LEDs are automatically dimmed thus conserving a large quantity of power on the lighting systems. It is estimated that about 40% of power is consumed during the running time of the LEDs. This system involves the real time monitoring and supervision of the lightings. Also a centralized supervision is enabled to completely turn off the lighting when not in use. Through this lighting management system it is estimated that about 69% of the power is saved over the lighting system. This provides an expected annual savings of about 157,811kWh, which is about 19% of the total power consumption. This system also needs less maintenance, and saves about 18.9K AED in the maintenance expense.

5.3 Analysis of Grid Tied PV System

The pictorial illustration of the grid tied PV system is shown in Fig.8. Solar energy is a conventional source of energy as the solar radiation from the sun is available throughout the year irrespective of the weather. Using solar energy as a substitution for the electrical energy not only conserves energy but also reduces the emission of carbon gases. Safety methods are strictly followed while installing the solar panels as the filling station has highly inflammable liquids. After appropriate selection of the installation areas safety precautions are double-checked by the corresponding authorities. The structural strength of the area is calculated so as to hold the installations. The cable routings are optimised to enable the durability of the cables and ensure their safety and channels.

This installation consists of 5 PV arrays, each of different type, inverters with harmonic filters, maximum power point tracking unit, surge arrestor, protective equipment and cables.

Fig.11. Light Management Energy Monitoring Dash Board

Fig.12. Installed solar panel arrays

Sl. No	ECM Description	ECM Description	Adjusted Baseline (kWh)	Guaranteed			Current Consumption (kWh)	Actual Achieved		
				Savings (kWh/yr)	Savings (AED)	Savings %		Savings (kWh)	Savings %	Savings (AED)
1	ECM 1	Programmable Thermostats	255,404	19,155	8,524	7%	236,248	58,743	23%	26,140.56
2	ECM 2	Lighting System	196,917	126,249	56,181	64%	73,132.78	123,784	64%	31,201.77

Fig.8. Installed solar panel arrays

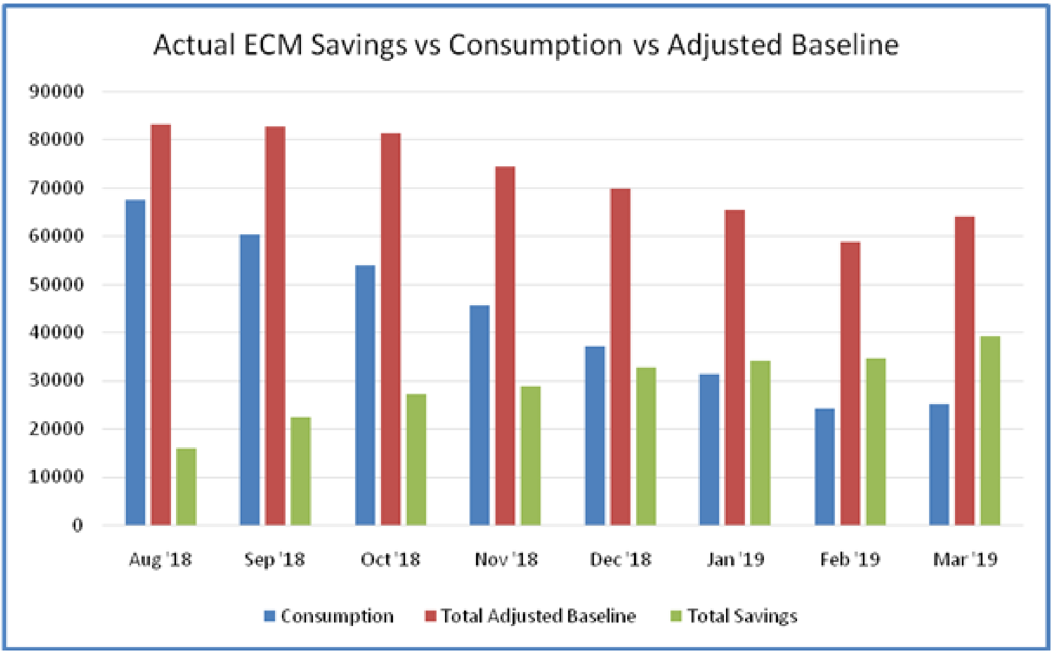

Fig.9. Comparison of the Actual saving vs. Consumption vs. adjusted baseline

Month	Reporting Period Consumption - kWh	Baseline Consumption - kWh (2016)	Bill to Bill Savings - kWh	Bill to Bill Savings - AED
Aug-18	64,121	77,310	13,189	5,869
Sep-18	66,425	82,796	16,371	7,285
Oct-18	63,705	80,407	16,702	7,432
Nov-18	55,408	74,782	19,374	8,621
Dec-18	46,036	71,722	25,686	11,430
Jan-19	49,633	62,509	12,876	5,730
Feb-19	51,845	57,985	6,140	2,732
Mar-19	37,305	61,027	23,722	10,556
			134,060	59,657

Fig.10. Bill to bill chart of the filling station

6. Conclusion

The energy consumption and the baseline analysis of the filling stations are shown in the chart as in Fig.9.

From the figure it is clear that with the increasing consumption the saving of the energy varies. As the days progress the conservation of the energy increases with the decreasing consumption. The clear bill to bill chart is shown in the Fig.10.

From the figure it is clear that the actual ECM savings was 234338kWh, accounting to 104280 AED. This is about 49% saving of the overall energy consumption. With the progressing year 36% of the total power conservation was guaranteed. The sustainability analysis proves that with the investment of 809,163 AED monetary saving of about 184,687 AED was achieved, which accounts for 40% of the total power consumption. At this rate the total investment will be recovered in 4 years and guarantees for power and money saving within 6 years. As the equipment in this system are guaranteed for 6 years, hence no maintenance or monitoring is required for the period.

The proposed technologies to conserve energy implemented in the filling stations ENOC 1079 and ENOC 1083. The corresponding results are obtained and compared against the actual consumption of energy without energy management systems. From the comparison analysis it is clear that the proposed techniques are effective and saves considerable amount of energy.

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Acknowledgements

The author declare that they have no conflict of interest.

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