ISSN No:-2456-2165

Electrical Energy Audit for Muritala Muhammed International Airport, Lagos

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Abstract:- The aim is to conduct an energy audit to know the energy consumption of Murtala Muhammed International Airport. It is discovered that the airport is made up of two components which are Airside and the Landside. The Airside comprises of Airfield lighting system in which the central runway and taxiway lighting system is made of Halogen fitting. Moreover the Landside component consist of the terminal building where all the lighting fittings installed are mostly fluorescent fittings and that of ground access includes external illumination are made halide, flood light and pressure intensity lamp ranging from 250W to 400W per fitting. If the energy consumption of the existing lighting system in and around the terminal building are replaced to LED fittings and energy efficient chiller that is easy to control and operate should be installed in the terminal building to replace the package unit ranging from 2PH, 10tones and 30 tones all having a total power output of 9MW with chiller unit of 2.8MW. Therefore, 6.2MW would have been saved. It will be more advantageous and will provide some level of relief on the load consumption with significant cost saving made in terms of bill payment to the electricity provider. The energy audit was centered on three major components which include the lighting system, HVAC systems, electric motors, Fault Statistics and Recovery Time, Feeder peak load & Feeder base load. Energy inspections were carried out facility by facilities across this airport so as to develop as strategic energy management plan for this airport. In conclusion recommendations were made on how to reduce energy consumption, also renewable energy should be incorporated into the airport power system so as to reduce carbon emission at point of generation.

Keywords:- *Energy Audit, Energy Saving, Energy Management, Airports, Energy Saving, International Civil Aviation Organization (ICAO), International Air Transport Association (IATA).*

I. INTRODUCTION

The energy demand of the aviation sector keeps increasing. The need for energy saving and energy audit is essential so as to control the energy consumption of the airports. It has been discovered that energy consumption cost for airport buildings (i.e. Check-in-desks, escalators, conveyor belts, service/visitor lifts, shops/restaurants and Runway/Airfield lighting) consist a high proportion of expenditure for airports[1,2]. Solving this problem, energy management has to be introduced into the Murtala Muhammed International Airport.

Energy Audit is the process of verifying, monitoring and analysis of use of energy including submission of technical report containing, action plan for improving energy efficiency with cost benefit analysis and a realistic plan to reduce energy consumption. It is basically to monitor residential, commercial and industrial energy consumption and to point out source of leakage is known as energy audit [3]. Factors that affect energy consumption at airports includes size of airport, Location, HVAC system and control unit, Traffic Density, Operation Hours and Architecture of airport [4]. Energy management system model for example, ISO 50001 is a strategy that contributes to the energy efficiency of public and private sector, improve their energy performance and reduce cost [5]. Murtala Muhammed International Airport (MMIA) ICAO (International Civil Aviation Organization): LOS, IATA (International Air Transport Association): DNMM is located in Ikeja, Lagos state, Nigeria. It processes close to 10 million passengers per year [6]. This airport has both residential and non-residential buildings. Energy audit was conducted for each of the facilities, to ascertain the energy demand, consumption pattern, reliability of their energy distribution network configurations and energy quality of supply so as to improve and enhance the present power distribution system for this airport.

The aim of this paper is to perform an energy appraisal for Murtala Muhammed International Airport so has to reduce energy consumption of the airport, also proffering energy recommendation for the airport to make it efficient and sustainable.

II. DESCRIPTION

Energy management, energy efficiency, energy audit and energy sustainable has been undertaking for various airports all over the world. This has been carried out to know energy consumption for airports, energy leakages/wastages, environmental impact assessment of the energy sources and sustainability of the energy sources as well as the economic implication.

Several papers have been published in the aspect of Energy management, energy efficiency, energy audit and energy sustainable of airports around the world [7-14]. A comprehensive review on Airports and environmental sustainability was conducted by the authors. The review was conducted for all airport infrastructures such as terminal buildings, airfields, and ground service equipment was audited to know which infrastructure in particular requires substantial upgrades. Environmental impact was conducted for an existing airport whereby life-cycle assessment, Scope

ISSN No:-2456-2165

GHG emissions were conducted. Solution where proffered on how aid airports in moving towards sustainability goals. It was found that for complete environmental evaluation, analysis such as life-cycle assessment, linking environmental impacts with operational outcomes must be conducted [7].

A sustainable airport energy management study was performed in Japan's Kansai international airport. Due to the energy demand of airport which is highly intensive [Incomplete statement]. To alleviate the environmental impact from energy consumption, airports have introduced a wide range of energy saving measures. This analysis covers till 2015. It was discovered that power, natural gas, hydrogen and wind power are the airports major energy sources. After the analysis, it was advised that energy saving options i.e. use of solar, hydrogen, and wind power, fixed electrical ground power for aircraft, widespread use of LED lighting, more efficient use of air conditioning systems and ceiling fans, and the use of low emission vehicles was the most visible solution to the energy and environmental complications [8].

An energy conservation strategies study for Taoyan, Songshan and Kaohsiung international airports was conducted. The authors firstly analyzed energy usage in international airports then developed energy saving plans specifically for air conditioning and lighting systems in airports. Based on survey result, it was suggested that regular maintenance should be considered the most effective and easiest way to conserve energy in air conditioning systems while lighting systems respondents decided indicted that improving regulation and control would be most effective option but choosing suitable light fittings will be the easiest to implement. The study basically concentrated on air-conditioning and lighting system. All these were considered putting the environmental implication of the airports into consideration [9].

Furthermore, an energy efficiency audit was conducted on Fatmawati Soekarno Bengkulu Airport in Indonesia. The study focused on the technical, economic and environmental impact of the airport. It was discovered that if the efficiency of energy utilization at the airport is increased, the budget savings from the airport management can be used for other purposes such as welfare of staff and upgrade of the airport. Regulation of the Minister of Energy and Mineral Resources (ESDM) number 13 of 2012 on Electricity Energy Saving Measures must be fully implemented in all government office buildings in Indonesia, as such wasteful practices must be curbed. In addition, alternative energy must be sought for sustainable airport management. It is expected that energy consumption can be reduced in airport operation in order to prevent greenhouse gas emissions. As regards energy efficiency rules made by the government such as Presidential Instruction No. 13 of 2011 on Energy and Water Saving and Regulation of the Minister of Energy and Mineral Resources No. 14/2012 on Energy Management [10].

In addition, a study on environmentally sustainable airport energy management using solar power technology using Adelaide airport, Australia as a case study. An environmental impact of energy usage, and checkmating the reliance on the traditional fossil-based energy sources and encourage use of sustainable sources of energy. It was discovered that solar photovoltaic (PV) systems has been adopted in many airport all over the world as part of their environmental sustainability policies making reference to South Australia-based Adelaide Airport, who have installed the largest roof-top photovoltaic system at an Australian airport. The paper empirically scrutinized the environmental benefits arising from the use of the system for Adelaide Airport and the solar photovoltaic (PV) ownership model adopted by Adelaide Airports Limited, the airport operator. It was found that the solar photovoltaic (PV) system installed at Adelaide Airport has delivered tangible environmental benefits by reducing its energy consumption by approximately 10% but also has enabled the airport to reduce its carbon emissions drastically [11].

A review of airport in terms of their energy use was performed. The review concentrated on the environmental and economic factors associated with airports which are of interest to airport managers. The cost of energy supply for airport managers has escalated. This article analyzes the main behaviors and energy trends at airports in more recent research, starting with the description of the main energy sources and consumers, the application of energy conservation and energy efficiency measures [12].

The authors gave in-depth knowledge of energy management and energy efficiency, how they can be utilized in airports all over the world to reduce cost and carbon emissions. It focused more on the management system model for energy efficiency and management i.e. International Standard Organization (ISO 50001). It was concluded that energy management systems in airports are necessary. It was advised that energy management system, energy management policy are essential to maintain sustainability in energy for overall profitability of airport, within scope of preliminary audit identification of energy consumption values and saving potential are requirements [13].

Airports all over the world are high energy intensive facilities. Airports are divided into two: the airside and the landside. Airside consist of equipment like offices, elevators, escalators, conveyor belt, terminal building lighting, HVAC system, equipment and machines used in shops, restaurants, banks while airside consist of navigation aids, runway light, maintenance facilities and apron lights [13]. Airports are rated according to their size, numbers of passenger, traffic density, and level of technology adopted by the airport [13].

Energy management comprises planning, training, monitoring, measurement, energy audit and implementation activities to provide energy efficiency. Energy is of core importance to facilities and buildings as a main source of operation. High percentage of cost of running facilities is energy cost. Environmental implication of energy sources is of great importance to countries around the world [10][13]. The fundamental aim of energy management is to produce goods and provide services with the least cost and least environmental effect. Energy management also means the prudent and effective use of energy to maximize profits (minimize energy costs) and enhance competitive positions. The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems [14].

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantities energy usage according to its discrete functions, Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme [14].

III. MATERIALS AND METHODS

This research was conducted by touring round the electrical equipment's and appliances of Murtala Muhammed International Airport (MMIA). This research was conducted with the electrical team of MMIA. Data for the study was obtained from a variety of documents, annual reports and records at our disposals.

For the purpose of this work, a detailed energy audit had been carried out across this airport. The audit was conducted on the lighting systems, heating and ventilating systems (HVAC) and electric motors. The approach used in conducting the energy audit exercises across this airport involved readings the ratings of each of the appliances around the airport.

A fluke 435 Power Quality Analyzer was connected to the low voltage end of each substation. Also multimeters were used as equipment's for the energy audit.

Also, the cable fault probability λ_c and $\lambda_x$was calculated using the Equations 1 and 2.

- $\lambda_X = \frac{Number\ of\ faults\ of\ component\ X\ per\ year}{Total\ Number\ of\ X\ units}\ [\![fault/(year)]\!]$ (1)
- $\lambda_C = \frac{Number\ of\ cable\ fault\ per\ year}{Total\ lenght\ of\ cable}\ [\![fault/(km-year)]\!]$ (2)

IV. RESULTS AND DISCUSSION

Murtala Muhammed International Airport (MMIA) is divided into components as shown in Figure 1. Both the Airside and Landside were audited in this study.

Fig 1: The Main Components of Murtala Muhammed International Airport (MMIA) Airport

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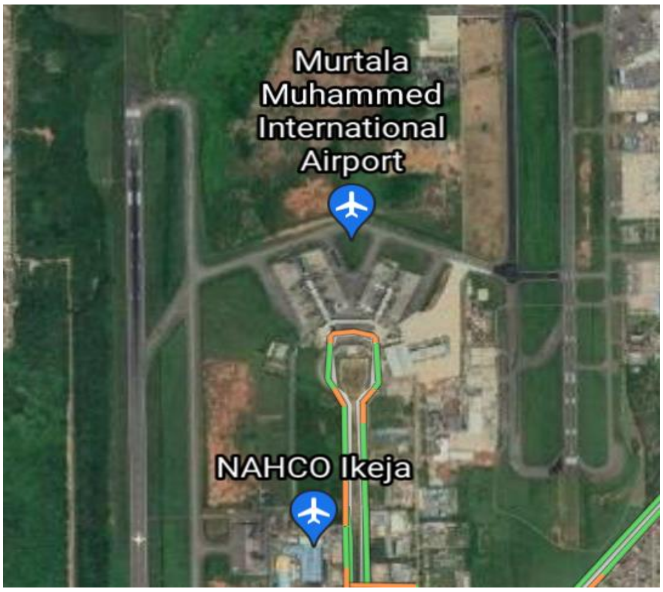

Fig 2: Satellite view of Murtala Muhammed International Airport (MMIA) [15].

The airport consists of Runaways, Taxiways, Apron, Perimeter Fence, Traffic Tower, Terminal Building Both Departure and Arrival Hall, Hotels, Premium Lounge, Security Post, Car Parks etc.

A. Lightings of MMIA

Lightings of MMIA was analyzed, both the fluorescent light bulbs (CFLs) and the light-emitting diodes (LEDs). The data gotten are shown in Table 1, Table 2, and Figure 3. The energy consumption compact fluorescent light bulbs using and energy consumed using energy saving light-emitting diodes (LEDs).

Table 1: The Difference In The Energy Consumption Between Fluorescent Tube And Light Emitting Diodes (Led) Within The Terminal Building.

S/N	ENERGY CONSUMED BY FLOURESCENT TUBE			ENERGY CONSUMED BY LED			% SAVING
	Type of fitting	No of Unit	Wattage	Type of light fitting	No of Unit	Wattage	
1.	2ft tube (20W per One)	8,944	178KW (178880W)	120 die-chasting panel (18W per one)	2,236	40KW (40,248W)	63.302%
2.	4ft tube (40W per one)	11,440	457KW (457600W)	600mm by 600mm (36W per one)	2,860	102KW (102,960)	63.506%
3.	5ft tube (65W per one)	3,120	202KW (202800W)	1200mm by 300mm (40W per one)	1,560	62KW (62,400)	53.030%
4.	Total Wattage		839,280W (839KW)	Total Wattage		205,608W (205KW)	60.737%

Fluorescent tubes of 2ft modular fittings is equal to 1 fitting of 160-die chasting panel LED, 2 fluorescent tubes of 5ft fittings is equal 1 fitting of 1200mm by 300mm LED.

Table 2: Table of wattage of fluorescent tube and LED

S/N	FLUOURESCENT TUBE(WATT)	LED (WATT)
1.	178880	40248
2.	457600	102960
3.	202800	62400
4.	8392830	205608

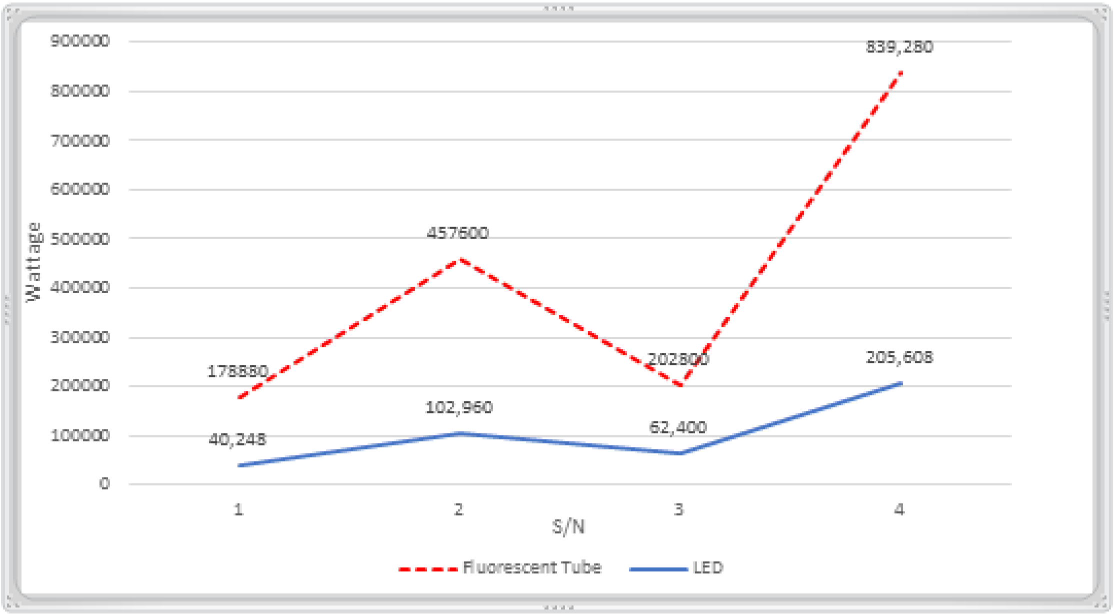

Fig 3: Graph of wattage of fluorescent tube and LED.

B. Central Cooling Unit (Chiller) of MMIA

The central cooling Unit (Chiller) is not serviceable and it has been out of operation for years. It was observed that the air conditioner package units of 10 tones and 30 tones were installed to every part of the terminal building while all the offices in the terminal building use split units of Air conditioner of 2 horsepower per unit as shown in Table 3. By the reactivating or installing new chiller unit, this will result to energy serving approach and developing an energy assessment matrix by reliability regulator to control the chiller units especially at night when airport operation is less.

ISSN No:-2456-2165

Table 3: List of Air Conditioner unit in the terminal Building:

Air Conditioner Unit	Unit (watt)	Quantity of the Unit	Quantity of Energy in Watt
10 tones Unit	35168 Watt	183	6435840 Watt (6.4MW)
30 tones Unit	105505 Watt	20	2110111 Watt (2.1MW)
2 horsepower slit Unit	1491 Watt	320	477248 Watt (0.47 MW)
TOTAL			9023200.4 Watt (9MW)

Note: 1 tone = 3516.85Watt and 1hp = 746 Watt
400 tones = 1406741.13 Watt (1.4MW)

If the Air Conditioner Units in the terminal building are replace with two units of 400 tones modern central chiller, then energy consume by the chiller units will be 2813482.273 Watt (2.8MW). Comparing the quantity of energy consumed by Air Conditioner Units and 400 tones modern central chiller, the energy difference will 90230.4 – 2813482.273 = **6209718.4 (6.2MW).**

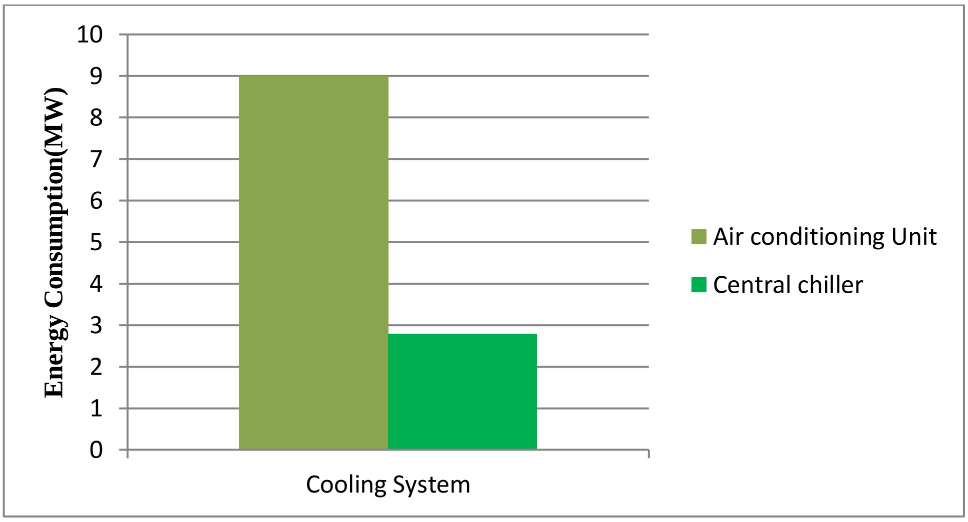

Fig 4: Graph of wattage of Air conditioning unit and Central chiller.

C. Calculated Fault Statistics and Recovery Time

Table 4: Faults and relevant data for the underground cables in Murtala Muhammed International Airport (MMIA)

Cable fault	**Lagos total fault**	**No of transformers**	**Total outages(hrs.)**	**Repair time(hrs.)**	**λ_c (fault/km year)**
2016	200	124	1019.2	507.2	0.0023
2017	170	136	753.2	400	0.0020
2018	113	153	632.8	237.8	0.0013
2019	106	170	564.48	360	0.0013
2020	85	182	520.8	173.5	0.0010
AVERAGE	135	153	802.26	370.4	0.0016

Table 4 shows the relative cause of power outage at various airports. Overloading and insulation problems accounts for majority of the problems encountered at these airport, this type of failure can be linked to aged underground cables and lack of retrofit at the appropriate time. Total replacement of these cables would be the best option and the oil insulated cables be replaced with XLPE cables for better performance and reliability.

D. Feeder Peak Load & Feeder Base Load

During the energy audit, it was discovered that MMIA has a total number of 97 transformer substations were identified across the entire airport grid while 83 transformer substations were audited during the course of the exercise, 8 of the transformer were not in use, 5 were faulty. The cumulative peak load across all the feeders on the airport grid is 17.9MW while the cumulative base load on all the feeder is 8.6MW. A fluke 435 Power Quality Analyzer was connected to the low voltage end of each substation. The details for each feeder is as shown in the table below.

Table 5: Feeder peak load & Base Load

S/N	FEEDER TAGS	FEEDER PEAK LOAD (KW)	FEEDER BASE LOAD(KW)
1	K12 (Ring feeder to K13)	0	0
2	K13	2294	1029
3	K16	1048	514
4	K17	2673	1346
5	K18	758	304
6	K19(Ring feeder to K20)	0	0
7	K20	892	437
8	K25	1581	428
9	K26	6149	3973
10	K27	1845	481
11	Station load (own consumption)	689	61
	CUMULATIVE PEAK/BASE LOAD	**17928**	**8572**

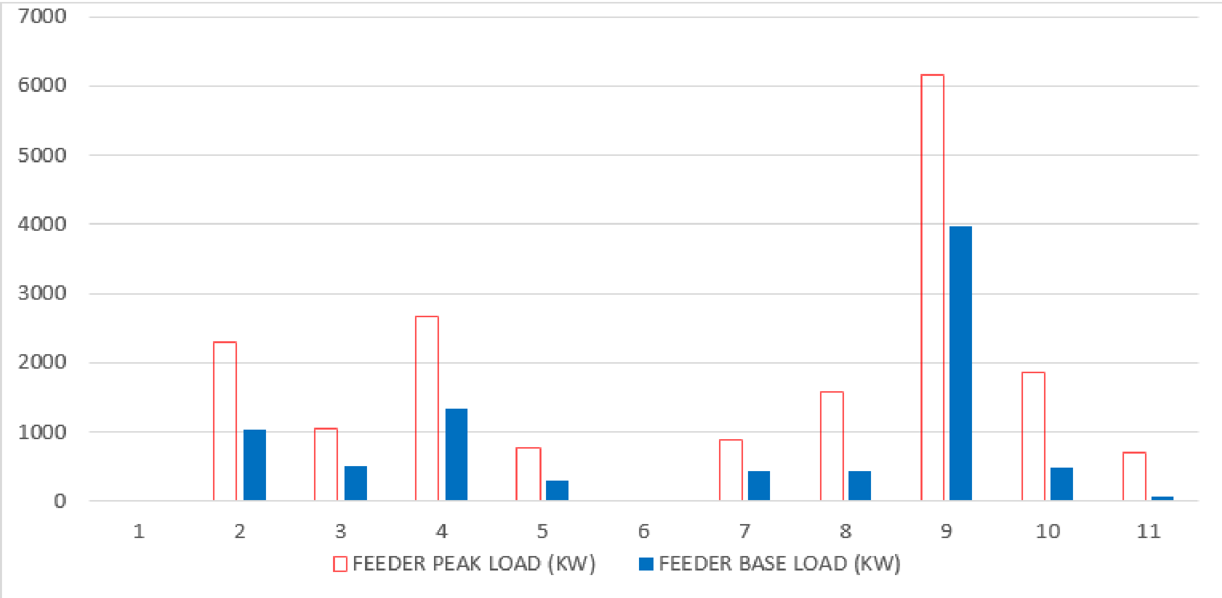

Fig 5: A bar chart of comparison of Feeder Peak Load and Feeder Base Load.

E. Energy Assessment of MMIA

The energy audit of Murtala Muhammed International Airport (MMIA) actually reveals the major electrical points consuming most of the energy in the airport which include the HVAC systems and motor. To every building been audited in these airport, 72% of energy is approximately consumed by the HVAC system, 23% is consumed by motors while 5% is consumed by the lighting appliances. The audit actually exposed a lot of flaws in the aviation industry in Nigeria concerning energy saving approach in Murtala Muhammed International Airport (MMIA) for instance, energy loss to lighting, HVAC and heating appliances is approximately 2.7MW and over the duration of just a month, #39,732,744.76 (approx. 40 million naira) could have been saved. With the use of energy meter, it was observed that the motor use in the conveyor, travelator and escalator of the airports were actually consuming more than their ratings.

V. CONCLUSION

Energy audit was conducted and the revelation of the Energy scenario in MMIA was revealed. The Motors, HVAC, and Lighting were indepthly analyzed, then conclusion and recommendations were made. Optimizing the energy use of a central cooling plant is one example of using a whole-system approach to reduce the energy use for heating and cooling buildings. Retrofitting of MMIA air conditioner unit in the terminal building is replace with two units of 400 tones modern central chiller will save MMIA 6.2MW. Scheduled preventive maintenance for motors in MMIA should be conducted so as to ensure efficient energy transfer. Gradual replacement of old equipment with new more energy efficient ones (retrofit) e.g. soft switching devices to reduce maximum demand value. Occupancy Sensor which is an indoor motion detecting device should be installed in all areas, also use of energy saving LEDs should be introduced. Other future works could include use of renewable energy sources for electricity generation.

REFERENCES

[1]. Marta Schluneger. *Energie-industrie*. Optimize electricity usage in Airports.

[2]. Bo Li, Wen Zhang, Jianping Wang, Junku Xu, Jixiang Su. IOP Conference series: Earth and Environmental Science .2017. Research and Analysis on Energy Consumption Features of Civil Airports. 94 (012134) pp. 1-6.

[3]. Anupama Gupta, Pallavi Verma and Richa Priyadarshani. A Review on Energy Management and Audit. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 2015. 4(2): 803-806.

[4]. Costa A., Blanes L.M, Donnelly C., Kaene M.M. Review of EU airport energy interests and priorities with respect to ICT, energy efficiency and enhanced building operation. Conference: International conference of Enhanced Building Operation. 2012.

[5]. UNIDO. (2015) New ISO 50001 publication to help smaller firms break energy barrier.

[6]. https://www.unido.org/news/new-iso-50001-publication-help-smaller-firms-break-energy-barrier

[7]. McLaughlin Liam. ISO 50001: Energy management systems 'A practical guide for SMEs. https://www.econbiz.de/Record/iso-50001-energy -management-systems-a-practical-guide-for-smes-mclauglin-liam/10011485702

[8]. Fiona Greer, Jasenka Rakas, and Arpad Horvath. 2020. *Environmental Research Letters* . Airports and environmental sustainability: a comprehensive review. 15: Pp. 1-24

[9]. Glenn Baxter, Panarat Srisaeng, Graham Wild. Sustainable Airport Energy Management: The Case of Kansai International Airport. *International Journal for Traffic and Transport Engineering*. 2018, 8(3): 334 – 358.

[10]. Ching-Cheng Chao, Cheng-Hsun Yeh and Chih-Han Yeh. Energy Conservation Strategies in Airports- A Case Study Of Taoyan, Songshan and Kaohsiung International Airports. Journal of Eastern Asia Society for Transportation Studies. 2017, 12: pp. 2074-2093.

[11]. Roilan. Energy Efficiency on Fatmawati Soekarno Bengkulu Airport. International Journal of Science and Research (IJSR). 2018: 7(2). 370-372.

[12]. Glenn Baxter, Panarat Srisaeng and Graham Wild. (2019). Environmentally Sustainable Airport Energy Management Using Solar Power Technology: The Case Of Adelaide Airport, Australia. International Journal for Traffic and Transport Engineering, 2019, 9(1): 81 – 100.

[13]. Sergio Ortega Alba and Mario Manana. Energy Research in Airports: A Review. Energies. 2016: 6(349): 1-19.

[14]. M. Kadri Akyuz, Onder Altuntas, M. Ziya Sogut, T. Hikmet Karakoc. International Symposium on Sustainable Aviation. Energy Efficiency and Energy Management in Airport. (2016). Pp. 398-401

[15]. Bureau of Energy Efficiency. Energy Management and Audit. (3) pp.54-78

[16]. Google Maps. https://www.google.com/maps/place/101233,+Ikeja/@6.5848699,3.3297477,14z/data=!4m5!3m4!1s0x103b9228fa2a3999:0xd7a8324bddbba1f0!8m2!3d6.601838!4d3.3514863