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SAVING ENERGY FOR ELEVATORS IN HIGH RESIDENTIAL BUILDINGS

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Abstract

Although the elevators consume electric energy approximately 4% to 5% of the total energy consumption in residential building but in a rise building which consist of large number of elevators, the amount of energy saving can increase and become more suitable accepted value. In this study energy saving of elevators can be achieved by design an electronic circuit installed in the control panel on the main supply of the machine. The electronic circuit can disconnect the power supply through remote control exist with the passenger. The measurements were carried out for one week on in residential building 12 floors, each floor consists one department, and the building bas one elevator. The results of the measurements concluded that: The total energy before and after using the electronic circuit are (99.8) kwh are (80) kwh respectively, i.e. the benefit is (18.8) kwh with percentage of approximately (19%). Although this value is relatively small, but for large, high-rise building using more than one lift, the value can increase and become more suitable accepted value.

Key words: elevators, energy consumption, high-rise building, achieved

I. INTRODUCTION

Over the last century the main sources of energy was represented either in cool or oil, never less, both of them are not renewable. Since elevator consume a considerable amount of energy, sacking for how to save this lost energy has become an objective in itself. There are different methods to save energy consumption of the elevator such as: saving energy during elevator operation in running mode, standby mode, and by using advanced technology of the elevator machine, in the cabinet equipment's, also it can be done in the landing doors by using advanced intelligence equipment's.

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Standby consumption in elevators is a very important issue. The standby consumption represents a large amount of the overall consumption of the elevator. The standby consumption can be attributed to the control systems, lighting, floor display and operative consoles in each floor, and inside the elevator cabinet. To minimize standby energy use, it is necessary to control or turn of non-critical components (such as air – conditioning, lighting) in the care. Energy saving of the elevator can be done also by the proper choose of the counterweigh as percentage of the rated load. In addition, the energy saving can be done by using advanced control panel. Using storing capacitor, which store the energy in the down directing and use it again. The main object of this study is to declare how much is saving energy during operation of elevator i.e in running and standby mode, this can be done by design electronic circuit used as electric switch which switch-off the main power supply from elevator.

II. THE PREVIOUS STUDIES

A. Saving energy during the operation of elevators

It is possible to save this energy in the mode of operation and standby (including idle mode) Table (1) explains the description of the machine, type (traction hydraulic) med of control (electronic or electromechanical) usage of building (residential, office, mall of university) number of floors characteristics (power of engine, nominal load and velocity) figure(1) shows the percentage of reserved energy, as disparity of values is due to type of elevator and the other factors in Table (1) while ether studies in Europe (13) did not reserve the hope in beneficial knowledge, as the consumption of reserve energy is affected by the congestion, operation aspects, means of control, the level of technology and that in order to reduce the reserved energy we have to manipulate the unimportant equipment like air condition and lighting units Table (1) about the main advantages of modified elevator Figure(1) total energy consumption in standby and operation mode.

Table 1: Main Features of the Elevators Audited.

Elevators	Description	Control	Type of building	Year of Installation	Velocity (m/s)	Nominal Load (kg)	Motor Nominal Power (kW)	N° of Stores
A	gearless traction elevator	Electro-mechanic	Residential	1982	0.6	300	3.3	3
B	traction elevator with VSD	Electronic	Residential	2000	1	430	5.5	9
C	gearless traction elevator	Electro-mechanic	Residential	1988	1	450	6.4	13
D	gearless traction elevator	Electronic	University	1997	1	630	11	9
E	geared traction elevator with permanent magnet motor (MRL)	Electronic	Office	2005	1	385	5.5	3
F	geared traction elevator with permanent magnet motor (MRL)	Electronic	Shopping center	2006	1	1600	16	4
G	hydraulic elevator	Electronic	Office	2005	0.63	640	14.7	5
H	hydraulic elevator	Electronic	Health clinic	2007	0.63	950	16	6

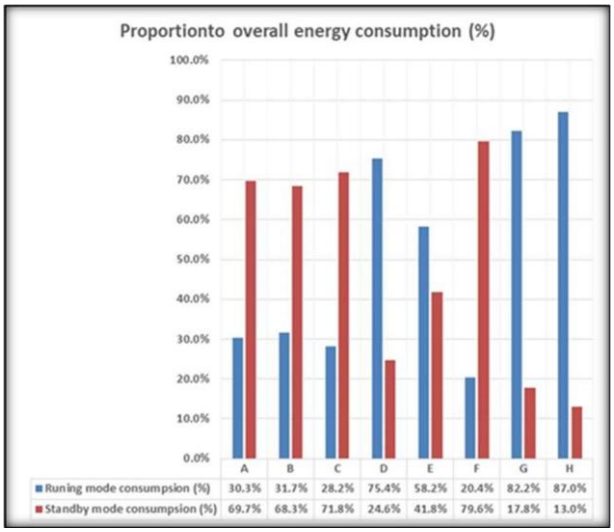

Fig 1: Proportion of standby and running mode to overall energy consumption of elevators.

B. Saving Energy by the advanced technology of elevator machine

There are several methods to save energy through advanced technology, and in spite that elevators consume 4% to 5% of total energy, this research suggests a method to analyze this consumption in administrative building in Finland however the simulation to this method led to a 6% in the rate of error (8).

This research compares the different machines, control systems through simulation in a high building of offices in 40 floors in Australia and it had been revealed that VVVF engine saves 30% to 40% of energy by SCD system, with mx machines, TMS 990 GAtm control system with considerable saving between the two systems, as consumption is lesser by 40% 70% by the use of my technology, as the saving through control method of 10% to 15% per day.

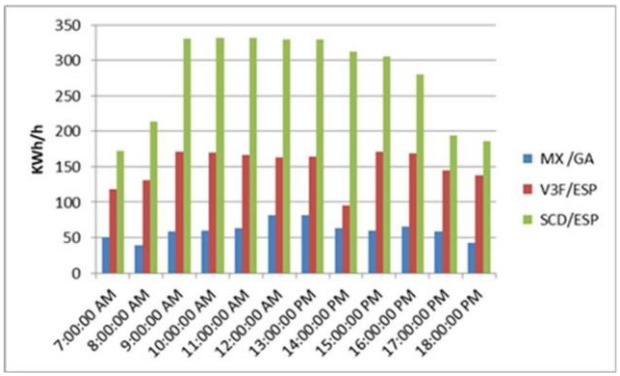

Fig 2: about simulation of energy consumption by SCD and VVVF and MX technics during daylight RE Mark.

- MX: technology with engine efficiency 90%
- GA: Control system
- Control system with EPS (the enhanced spacing system) TMS 9900
- Control system with Optimum Routing Principle (ORP TTMS9900GA)

The Comparison of the impact of different machines, driving systems, upon the examination of offices and high buildings such as the building of 40 floors in Australia [11] in An, ordinary day the V3F engine provides 30% to 40% compared to SCD system with MX machines and TMS 990 GAtm The Saving is Mark through the two methods. As the saving is 40% to 75% by my method and through the control of operation from 10% to 15% as MX machines equipped with TMS 990 GAtm provide a friendly environment elevator.

III. CONCEPTION OF HOIST SYSTEM

the ascension 2021 (4) suggests many other ideas for the efficiency of energy without a need of substitute system.

A. Consideration of hoist system

Hydraulic system and traction are the most used in elevators however hydraulic system consumes considerable amount of energy beside the costly maintenance, while traction without gears is better as come systems could be smaller of 10% and consume lesser energy beside the energy from motion of elevator downward and we can convey it to useful energy as we can't use it as it is.

B. Install Automated Controls

Install automated controls that will automatically turn off lights, fans, air conditioning and other systems when the machine is not in use. The standby mode is when the elevator consumes most of the energy. You could end up saving up to 70% of the energy consumed by the system if you take control over what it does during the standby mode. The control systems have received some of the biggest improvements in this field. You can find elevator systems and software that can implement several types of energy-saving concepts. Some of the most effective ones that you can embrace are as follows:

- Standby Mode: The program can control the system automatically with interruption of power from unimportant equipment's when the elevator is idle, as the system resumes with a push of button.
- Data Logging: these systems can collect data about traffic for elaboration of strategies for more efficient control in elevators, as the program can and floors.

C. Install LED lighting

Lighting consumes tiny part of energy required by elevators as the replacement of incandescent or flouriest lamps by led can assist in saving 80% of consumed energy on lighting as led lamps can be used for decades instead of replacement of lamps frequently.

D. Consider hardware improvements

Beside the melioration of hoisting system, we can think about the following amelioration of equipment and elevator systems for efficiency of energy, therefore if your elevators depend on direct current engines you have to replace them with alternating current that saves energy for 50%.

- Systems of Landing: The replacement of old landing systems based on strip or magnet with new systems that stop the cabinet immediately and does not require the operation of engine for long periods.

- Replace Old Used Starters with New Ones: Door pushing motors: you can replace the door engines with new ones which are in standby mode when they are idle and resume the operation in case of need.
- It is possible to save 20% of energy if you replace door operation units with new substitute, however before you know about the steps of energy saving you have to have strong knowledge about the systems that consume the considerable amount of energy.
- type of machine: the equipped machines consume 30% of energy compared to machines with gears.
- The engines: the use of renewable engines can save the energy greatly, beside the production and resumption of lest energy with economy of costs to 50%.
- The Installation of led lamps can reduce energy to 80%

IV. HARDWARE / SOFTWARE IMPROVEMENTS

The improvements that could be made for elevators according to (Liftronic, 2018) [12] imply:

A. Hardware improvements

The landlords should verify if their elevators are hydraulic of traction type, as the hydraulic consists of piston in a cylinder that hoist the cabin through oil pumping of electric motor as this method consumes more energy than of traction, with costly maintenance however the new waves can improve the hydraulic type.

The traction elevator moves up and down on steel rope with opposite balance weight which share a part of load therefore the traction elevators are more efficient than Hydraulic the traction elevators have another advantage as they do not a room for engine due to redesign of engines to cope with hoist shaft for lesser heat and energy.

According to Amanda and Ramadhan 2020 [3] the renewable engine is a push system in and elevator that produces electric energy with use of electric energy through the advantages of the elevator, difference of weight between hoist cage and load balance, with the resumption of energy through the building electricity used in other electric equipment as this engine power reaches 38.6 kilo watt that produces 29 kilo watt of renewable energy.

Another benefit from this technology is in synchronous engine and permanent magnet, as this technology provides 96% of efficiency with a great reduction in energy consumption as elevators consumes 8% of total energy since 20 years as they used actually use 2% of total energy.

B. Software Improvement

The magnificent improvements in last few decades had been in the control systems that save energy.

- Standby mode as this option stops lighting automatically it the elevator is not used for a while, and which operates anew upon a press of a button.
- Data registration: the tools for the studies of traffic through the data about frequent usage, number of floors, climate hour in order to calculate energy consumption.

C. Benefits of energy-saving elevators

- The smooth acceleration of cabin and brakes for more comfort of passengers, less noise and vibration.
- Reduced weight of winch
- More lifetime for the machine due to less burden on worm gear and the lining of brakes.
- The limitation of starting current for driver reduces energy consumption during start-ups up to 2-3 times, reduces driver's heating temperature which allows expanding its life.
- In energy-saving elevator's main drive speed is installed. It has lower weight, dimensions, and prize in compared to traditionally applied double-speed drive.

V. POTENTIAL FOR ENERGY SAVING FROM MOTOR DRIVE TECHNOLOGY AND SMART CONTROLS

Tukia, et al (2019) [19] conducted a case study about the pattern of consumed energy saving within the week with the aim to assess the efficiency of energy, and analytic concepts of energy systems by simulation of total consumption in New York with presentation of more scope of analysis as the results had shown that elevators consumes more than 1% of total annual consumption however the percentage in hour varies form 0.5% to 3% of total demand of energy beside the necessity of confident prediction of total energy consumption of confident prediction of total energy consumption there are two methods for efficient use of energy however this does eliminate the need of energy caving components like engines, discs, lighting, energy supply as we have to consider the modality of work and their functions, as there are some components that could be shut off after each usage bike car lights, fans, connection buttons, screens. The management of control system affects the amount of energy consumption with the rich choice of acceleration.

In the same regard, Kroll (2014) [10] states that elevators' energy use can be reduced through a varletry of means, including the use of more efficient AC motors and regenerative drives, but this objective does not always get top priority. Most facility managers look first to the lighting, heating, and cooling systems when searching for opportunities to cut energy use in their buildings. That's an understandable approach, as these systems together account for more than half of the energy used by commercial buildings, according to the U.S. Department of Energy. Furthermore, elevators that combine multiple cabs into one shaft maximize facility's efficiency in four ways which are:

1) more core space, 2) added movement capacity, 3) smaller motors, and 4) elevator sleep mode (Reebenacker, 2019) [16].

A. Standby energy consumption

Elevator F is the most advanced as it consumes largely the reserved energy of 2271 kw per hour in standby and 582 kw in operation made, therefor substitution with traction elevators can reduce costs, through the engine that convey the descending power of lift to electric energy and which will feed the building grid. The values of energy saving is very important to factories as rue company has begun to fabricate LP-0463 BE elevators on 2008 that controls the speed of motion and the doors with great caving of electric energy of 34.7% with smooth motion of lifts and the mean consumption of energy and coupler is 54.3 kilo watt per hour while the control of speed is 31.54 kilo watt. The saving energy

elevators are used widely to replace the worn off elevators, which save the costs to 30% as they do not the balance weight or fixation parts. (ACE, 2015) made a study about the methods to reduce energy consumption in India with great development in years to come for smart cities that will rise the demand on these elevators.

(Alcodmany, 2015) [2] made A. Research that assisted in modern advances in elevators technology as he had collected all the information about the design, and the results of this study had been used in world trade center in New York, and shanghai tower, Khalifa tower in Dubai, kingdom tower in Saudi, green modernity project for empire state in new york as this research discusses the futuristic vertical transmission in space elevator, electromagnetic hoist technology as these new technologies enable the engineers to design new shapes of multi uses.

The required energy consumption had been greatly reduced in the last twenty years with the permanent magnet and synchronous engine, however this reduction will be difficult and will be through the other elements like lighting fans doors and frames. The consuming and productive energy elevators are possible through solar panels, and substitution of old equipment and investment is new technologies.

VI. The Role of using Green Elevators in Saving Environment and Reducing the Running Cost

Energy efficiency and protection of environment are two main elements as green buildings use less water energy and other materials therefore the manufacturers seek to reduce the energy and preservation of environment (Boma Magazine, 2021) [5]. There is a low number of green products in the manufacture of elevators as there are designed to achieve efficiency and safety as the attachment of these to the elevator can reduce the consumption, as the led lamps can last long other than incandescent and florescent lamps, therefore it is necessary to substitute the worn control system.

Champion elevator (2022) [6] depends on electricity which is the main sour of energy but in the eighties, the elevators shafts had been integral in design of sky scrapers, with the invention of first electric elevator on 1880 and that on 1889 the first electric lift had been installed in a commercial building, as the few last year's show the tremendous advances in elevators and methods of maintenance therefore 1889 we should be aware about the last developments that keep these systems safe and functional. The year 2017 had been busy in the industry of elevators beside new renovation in the field of construction, about the modality of elevator mechanism, and maintenance, through the smart green elevators up to the internet elevators, as these innovations are tremendous (Schwartz 2018) [18].

A. The Numbers

What is the amount of energy that can be saved from this improvement? you can expect the following environmental solutions from liftronic Pry limited company [12].

- LED lighting that reduces energy to 90% with the increase of Age of lamp to years through substitution of M and GU10 lamps of the rescued tension with led of low cost and higher output.
- Machines without Gears that achieve improvement at 30% and more in the efficiency of energy compared to Machines used in the applications of elevators.
- Control of the engine, which achieves great saving in energy cost that reaches 50% besides the resumption of excess energy through renewable engines.

- Doors operating units that improve the efficiency of energy to a percentage of 20% compared to actual systems.

B. The takeout

The improvement of as elevators is not merely an option for any landlord as it is mandatory at definite stage therefore the benefit from energy saving for now instead of later on is a logic matter. If you do not improve your elevator (or maintain it according to the minimum criteria of fire safety and client satisfaction) you will have a higher bill, therefore carry on the necessary modifications immediately. Elevators are engineered designed systems, they are ready made products for every building as simulation programs are actually available as we did not found out simple and beneficial measures of efficiency and as the possibility of energy saving is relatively small we do not recommend to modify the elevators, for it is more important for environment protection energy to announce the probable saving on its website which will be among the best practices for new installation with the recommendations about the modern modifications to obtain the benefits of energy from the improvement for other causes the technology of elevators is in steady progress, as the majority of these changes in the engines and new programs will economies energy will the existence of simulation programs will allow the producers and their agents the possibility to calculate the rate of economic return from the investments, on the other hand the options available to clients are not effective about the cost as they are additional advantages like short waiting time or reduction of noise and vibration) This simple method is not very efficient about cost and efficiency of elevator as it is in Hong- Kong which is a densely urban environment; while it is not possible to find a direct method from new modified advantages smart achieve better efficiency and low consumed energy.

VII. DESIGN OF THE ELECTRONIC CIRCUIT

The function of the electronic circuit is operated ad electric switch which disconnect the power supply from the elevator, if the electronic circuit installed on the main supply, it disconnects the current from the machine and cabinet, but when installed on ancillary power point, it disconnects the current from ancillary equipment's in the cabinet (light, ventilation, auxiliary battery …. etc.). It operates by remote control exist with the passenger; it gives an electronic wave to the signal receiver.

As shown in fig (3) the electronic circuit consists of signal receiver, which is operate of (12v DC), connect to relay which is also operate of (12v DC). The output of the relay connects to two internal and external com, which represent the request of passengers from the landing door and cabinet through two terminal strips, and the other terminal strip feed the relay time, The main object of the relay time is to allow to complete a significant time to complete the journey of the elevator, i.e to complete the travel for building in both up and down direction. When pressing the remote control, a signal is given to the signal receiver for ten second, then operate the relay consequently operate the relay time to start for counting time equal to (3) mints, then after this (3) mints, to it give a signal to the contactor to witch off electricity from elevator.

The process of switch off the main supply, can be done when the contactor operates – through 3 – phases, which switch of the main supply, for the elevator. In this case the energy meter calculates the energy consumption for elevator’s machine and equipment's in the cabinet, in all mode of operation

(running, standby). Fig (4) stows the position of electronic circuit in the control panel, while in fig (5) in the energy meter measures the total energy from the main supply.

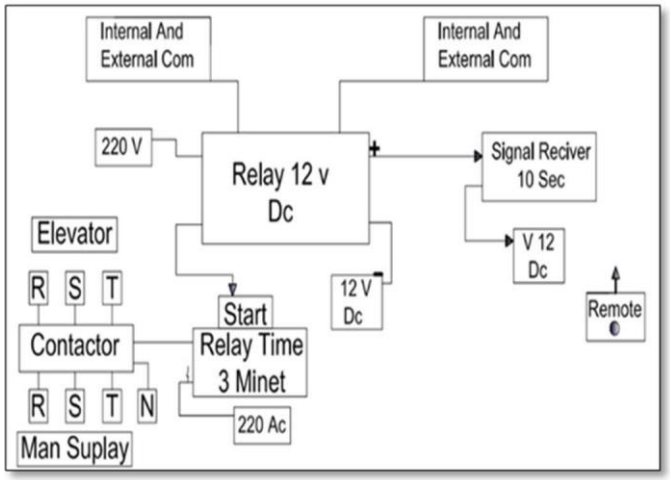

Fig 3: Block diagram of the electronic circuit

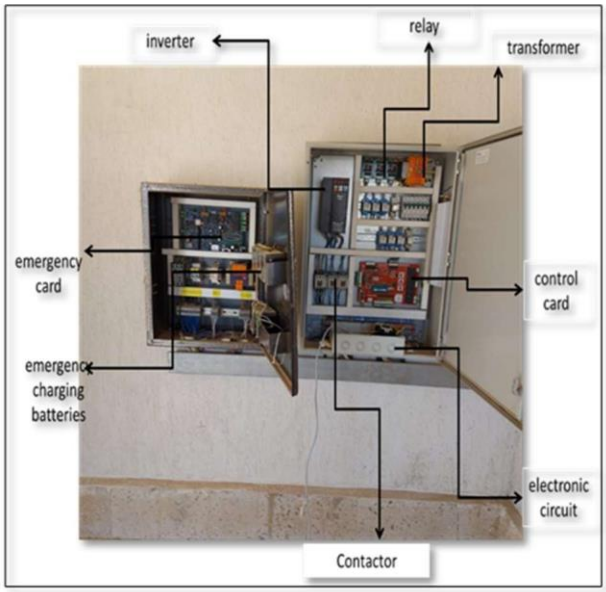

Fig 4: position of electronic circuit in the control panel

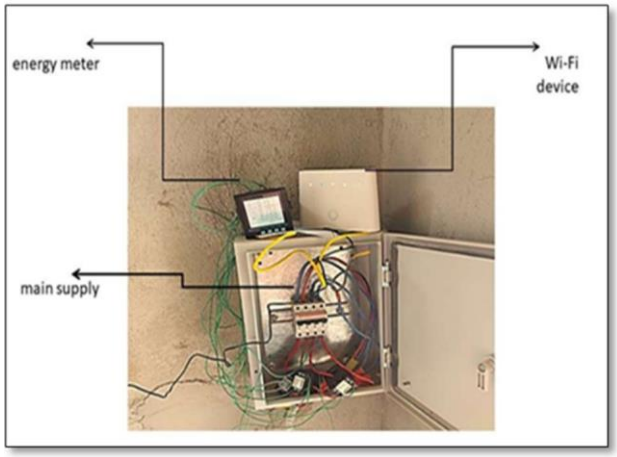

Fig 5: energy meter Measures main supply

VIII. REAL TIME ANALYSES OF POWER DRAWING FROM MAIN SUPPLY

The measurements were carried out for one week from (8 to 14) October (7 days). As known the power is proportional to the square of the current, then the real-time analysis of the current can be used instead of the power consumption. The results of the measurements are Shown in figure, (6) for this week. As shown from this figure, the maximum value is (14.225) ampere and the minimum value is (0.019) A. then the average value is (1.466) A. In addition, it can be observed that, the other sub peak is low, but there are many periods with small values of current, but not equal zero.

Figure (7) shows the current drawing, from the main supply in the followed week begin from (15 to 21) October. The maximum value of the current is (8.66), the minimum value is equal to zero, and repeated many time (i.e.) the lift is not operated, or standby mode. In addition, the sub peak values are large, hence the average value is (1.316) A. The above results declare that the average value of the current drawing for the two followed weeks are the same, consequently the power. Because the energy is equal to the power multiply with time, and the time is constant (one week), then it allow.to compare the effect of installing the electronic circuit in the two following week on the energy saving, which will be detected by item (4).

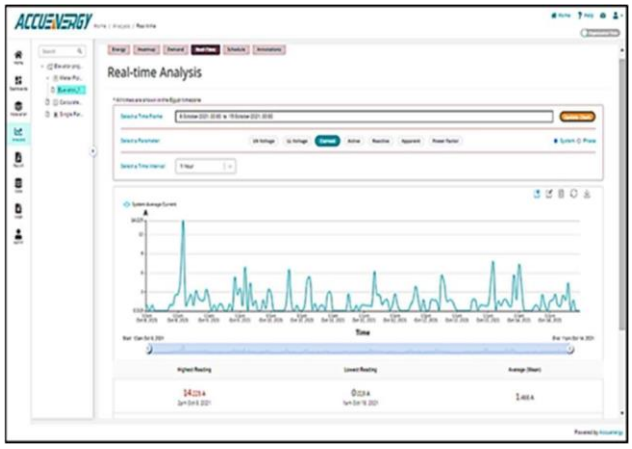

Fig 6: the real time analysis (of the current) from 8 to 14 October (7 days)

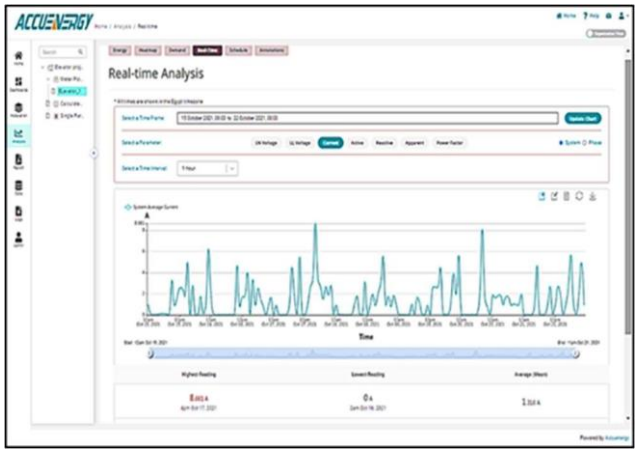

Fig 7: the real time analysis (of the current) from 15 to 22 October (7 days)

IX. THE EFFECT OF INSTALLING ELECTRONIC CIRCUIT ON THE ENERGY CONSUMPTION OF THE LIFT

A. The measuring conditions are as follow

The energy meter is connected on the main supply in control panel, i.e., it measures the total energy of the lifts machine and energy consumed in the cabinet ancillary devices which include (lighting, ventilation, heating, alarm devices, and emergency battery supplies). When using this electronic circuit, (remote control) it disconnects the power supply from both machine and ancillary devices.

Fig (8) shown the energy consumption of the elevator before installing the electronic circuit for the week from (8-14) October 2021. From this figure it can be observed that, the maximum peak attains a value of (22.4) Kwh at (8) October. The total energy consumption of this week is the sum of the individual one which equal to (99.8) kWh (the sum of the blocks), i.e when the lift is operated. The average value of this week is the division of the (99.8) per (7) days, which equal (14.3) kWh. The variation of the above values is depending on the traffic analysis of the passengers used the lift which is differ from day to another.

Fig (9) shows the consumption after installing the electric circuit for one week from 15 October to 21 October. The maximum values of energy consumption is happed in a day (17) October and attain a value of (13.8) kwh, while the lowest value happened on (21) October and attains a value of (8.1) Kwh. The total energy consumption in this week is (81) Kwh, and the average value through this week is (81/7) =11.6 Kwh.

The total energy before and after the installing of the electronic circuit are (99.8) Kwh and (81) Kwh respectively i.e., the benefit is (18.8) Kwh with percentage of (18.8/99.8) equal approximately to 19%. Although this value relatively small, but for a large, high-rise buildings using more than one lift, the value can increase and become more suitable accepted value. Fig (8, 9, 10) shows the energy consumption before and after installing the electronic circuit.

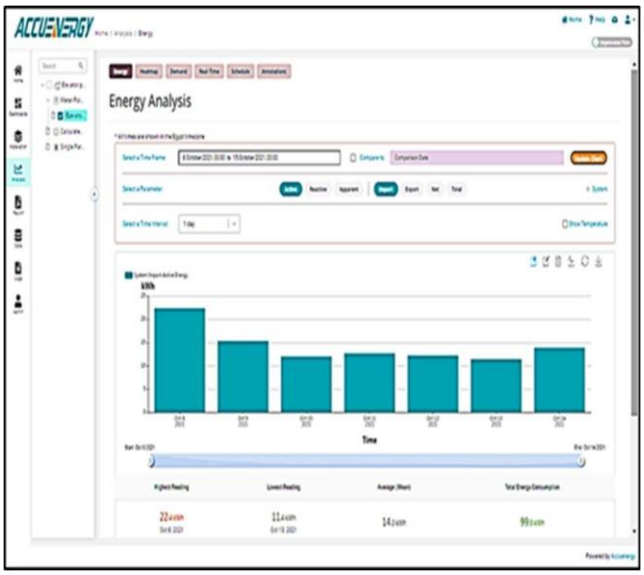

Fig 8: the energy analysis of the energy consumption before installing the electronic circuit for one week from 8 October to 14 October

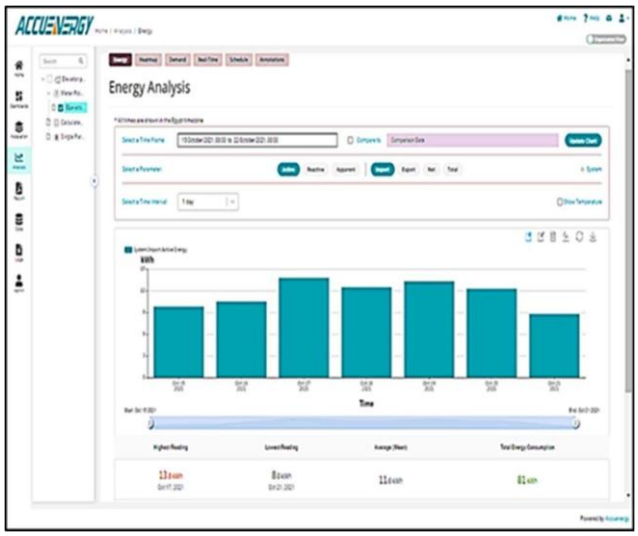

Fig 9: the energy analysis of the energy consumption after installing the electronic circuit for one week from 15 October to 21 October

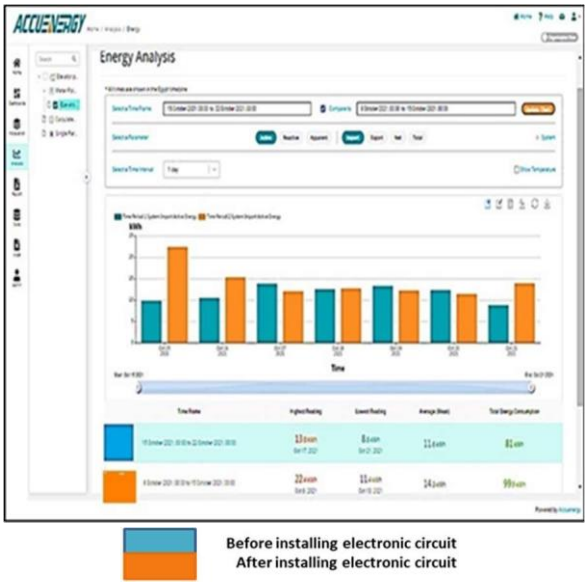

Fig 10: Energy consumption comparison before and after installing the circuit installing the electronic circuit.

X. Conclusion

Saving energy consumption of the elevator can be achieved by different methods as mentioned in the introduction. One of them is saving the energy consumption during the operation of the elevator. This study concern with saving energy during the operation of the elevator, by designing an electronic circuit installed in the control panel, which switch-off of the power supply after (3) mints, -as maximum value- and connect it again, when the passenger uses the elevator through remote control. The measurements were carried out on residential building consist of 12 floors, each floor contain one dwell, with area of (120) m2, and building has one elevator.

The results of the measurements are as follow: the total energy consumed in one week before and after using electronic circuit are (99.8) Kwh and (81) Kwh respectively, i.e., the benefit is (18.8) Kwh, with percentage of approximately (19%). Although this value is relatively small, in high rise building using more than one elevator, the value can be increased and become core suitable accepted value.

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