Energy Performance Evaluation of Retail Outlets – Case Study of anAir-Conditioned Supermarket in Kerala

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Abstract – *Retail market in India contributes 10 % of Gross Domestic Product (GDP) and 7% of employment. The grocery and food retail outlets including supermarkets and hypermarkets form an integral part of the Micro Small and Medium Enterprises (MSME) sector. Energy is one of the key resources utilized by these retail outlets for the day-to-day operations thereby contributing to a vital share of their annual turnover. Increased greenhouse gas emissions as a result of India's increased energy consumption and the country's future dependence on fossil fuels to serve its energy security have raised serious environmental concerns. Since, new technological trends in Energy Efficiency and sustainable development are being introduced in all type of industries including MSME's, potential areas for Energy optimization through Energy performance improvement and sustainable working practices can be identified.*

An energy audit is an effective method used to survey and analyze energy flows in any system and arriving the energy balance of the system. This methodology is utilized to evaluate energy performance of a supermarket based in Kerala. Suitable opportunities to conserve energy through energy efficiency enhancement, behavioral change practices, renewable energy integration etc. are suggested. The energy usage is crucial for the industries and supermarkets using various equipment for 24 hours. Through preliminary energy audits we can determine the energy consumption of each equipment using instrument and analyze the potential of energy optimization. This paper describes the energy saving potential of various electrical equipments at an air-conditioned Supermarket in Kerala. Climate change is an important factor while analyzing the energy conservation and efficiency. As climate change becomes an important factor offsetting the carbon footprint become necessary. The carbon footprint of various equipment was also determined using the energy consumed. Offsetting of carbon footprint can only be done by switching to energy efficiency, its conservation and usage of renewable energy.

Key Words: Energy audit, Carbon footprint, Energy efficiency, Energy demand

1. INTRODUCTION

The advancement in technology and urbanization has caused an increase in energy consumption in India. The energy generation plays a vital role in the economic uplift of India. But the continuous usage of conventional energy sources causes depletion of the same soon. The emission rates are also considerably mushroomed due to the vast utilization of fossil fuels for energy generation in industrial and transportation sector. Hence significance of energy conservation and energy efficiency are not emittable. In such circumstances energy audits become necessary practice to be adopted. Through energy audits energy saving potential can be increased adopting energy optimization recommendations. Energy efficiency, termed as 'the fifth fuel' by the International Energy Agency (IEA), will play a pivotal role in determining an optimal energy portfolio for India.

The energy audits carried in supermarkets help in understanding the equipment with wastage of energy. Most of the energy consumption can be minimized by finding the reasons behind over usage of energy and building up proper strategies to save energy. Since, new technological trends in Energy Efficiency and sustainable development are being introduced all type of industries including MSMEs, the grocery and food retail outlets including supermarkets, hypermarkets etc. form an integral part of these MSMEs. Hence, potential areas for Energy optimization through Energy performance improvement and sustainable working practices can be identified.

Consumption of energy in supermarkets will depend on various business practices, store format, and shopping activity, the food preparation, preservation, storage and display equipments. The energy consumption in retail outlets is normally described in kWh/m^2 sales area per year and is determined as the Energy Performance Index (EPI) of the retail outlet. The EPI can be used to compare the various energy consuming equipments in supermarkets that merchandise similar quantities of ambient and refrigerated food products and food and non-food products.

Energy optimization of stores can be achieved by judicious usage of Energy, proper Energy policy interventions and cleaner energy utilization without affecting quality of groceries maintained including the cold chain connections. The study was conducted by separating the retail outlet into several zones to avoid the complexity and to identify the zone wise energy consumption and its related parameters. A considerable importance was given to the air conditioning and refrigeration zones as it consumes more energy respective to other zones. The pie chart showed below depicts the percentage energy consumtion of various sector which includes cooling, refrigeration, Ventilation, Lighting and other miscellanous sources. The load share in percentage is shown below:

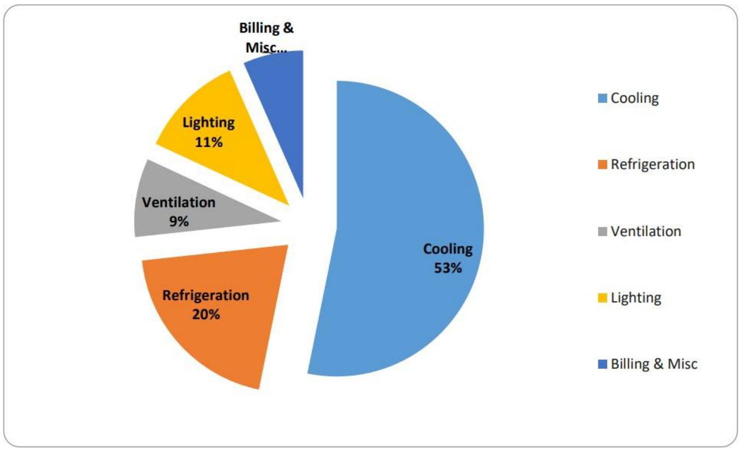

Chart -1: Breakup of Connected Load category wise

2. ENERGY PERFORMANCE

Energy Performance of a system is generally evaluated using Specific Energy Consumption (SEC) of the system, ie Energy input to a specified unit of product. In this case the Electrical equipment and appliances connected to the power supply system of the facility is considered as the system, Production is the total sales area measured from the built-up area of the facility. The average annual SEC is found to be 295 kWh/m2 Sales Area/Yr.

Table -1: Energy consumption statistics of various equipment

Equipment	Connected load	Daily Energy Consumed (kWh)	Monthly Energy Consumed (kWh)	Annual Energy Consumed (kWh)
Air Conditioning	12.6	83.16	2494.8	30353.4
Deep Freezers	1.846	34.66	1039.8	12650.9
Bottle Coolers	1.557	21.99	659.7	8026.35
Visi Coolers	1.355	22.62	678.6	8256.3
Ventilation	2.035	22.07	662.1	8055.55
Lighting	2.72	47.74	1432.2	17425.1
Billing & Misc	1.57	6.77	203.1	2471.05
Total	**23.683**	**239.01**	**7170.3**	**87238.65**

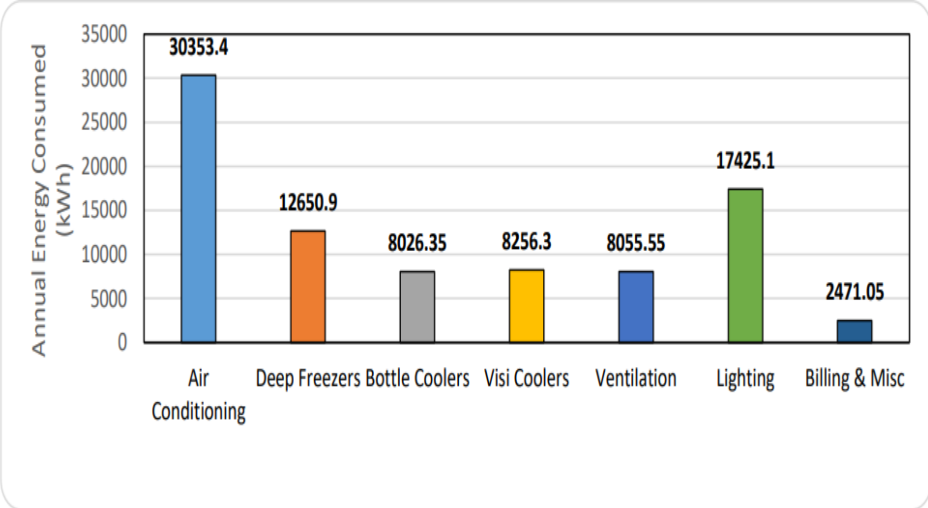

Chart -2: Annual Energy Consumed by various equipment

Table -2: Energy Performance Statistics

Parameters	Value	Units
Daily Energy Consumed	214	kWh
Daily business hours	11	Hrs.
Annual no of working days	365	days
Annual Energy Consumed	**78110**	**kWh**
Annual Energy Cost @ 9.3 Rs/kWh	726423	Rs
Total Sales Area	265.3	M2
Specific Energy Consumption	**295**	**kWh/Sales m2 /Yr**
Annual Carbon Footprint @0.7 kg/kWh	54.68	tCO2
Specific Carbon Footprint	0.21	tCO2/m2 /Yr
Renewable Energy potential	25	kWp

3. REFRIGERATION SYSTEM PERFORMANCE

The refrigeration system in the facility consumes about 33% of overall energy consumption. Retail food refrigeration, or commercial refrigeration, includes equipment designed to store and display chilled or frozen goods for commercial sale [1]. The equipment used for refrigeration are Deep freezers for preserving meet products, milk and ice creams, Bottle coolers and visi coolers used to preserve and chill cold beverages, milk and milk products, chocolates etc. It can be seen that the facility owns a very few numbers of these equipment, rather the equipment is installed by the product manufacturers to preserve their branded products. The operational costs in connection with energy consumed by this equipment are borne by the facility. Improper temperature settings of most of this equipment by the product manufacturers leads to incorrect cutoff of compressors and result in higher energy consumption. These equipments function throughout the day, round the clock, round the year. Preservation temperature varies from product to product. Energy consumed by the refrigeration equipments depends on various parameters like set temperature, storage volume, type of compressor control, number of cabin openings for loading and unloading products, clearance and position of installation, frosted ice etc. Hence the energy conservation potential in refrigeration equipments seems to be very high through set temperature optimization, timer operation, proper positioning and adequate clearance etc.

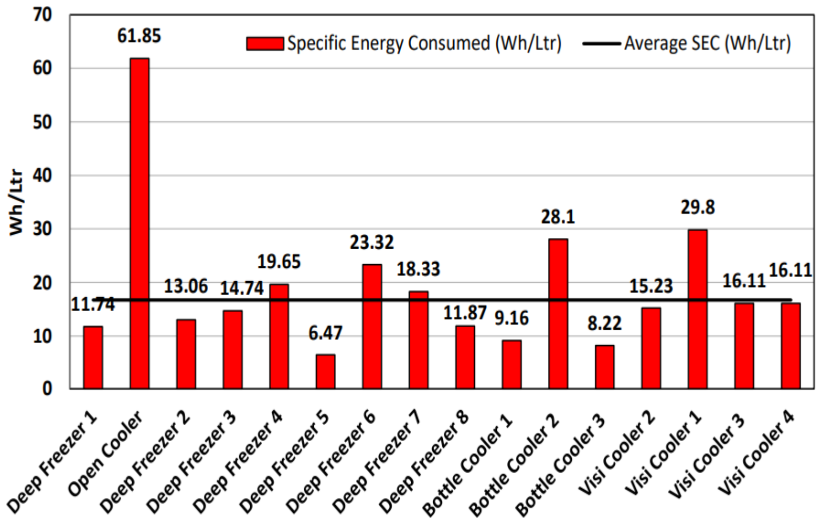

Chart -3: Comparison of Specific Energy Consumption in Wh/Ltr

4. CARBON CONTRIBUTION

Climate Change is considered as the greatest ecological, economic and social challenge of our time. Today the faster development demands utilization of more energy. The growing contributions of human generated emissions as a byproduct of our lifestyle are responsible for forcing the “greenhouse effect”. The “carbon footprint” describes the CO2 emissions of a given product or process for its whole life, but has several definitions. The annual volume of CO2 emission contributed by all the fuels and electricity used by the facility measured in tCO2 is called Carbon Footprint. Annual Carbon footprint corresponding to energy consumed in the facility is to the tune of 61.21 tCO2. Major contribution is from Air conditioning and Lighting.

Table -3: Annual Carbon footprint for energy consumedBy various equipment

Equipment	Annual Energy Consumed (kWh)	Annual Carbon Footprint (tCO2)
Air Conditioning	30353.4	21.25
Deep Freezers	12650.9	8.89
Bottle Coolers	8026.35	5.64
Visi Coolers	8256.3	5.81
Ventilation	8055.55	5.65
Lighting	17425.1	12.21
Billing & Misc	2471.05	1.76
Total	**87238.65**	**61.21**

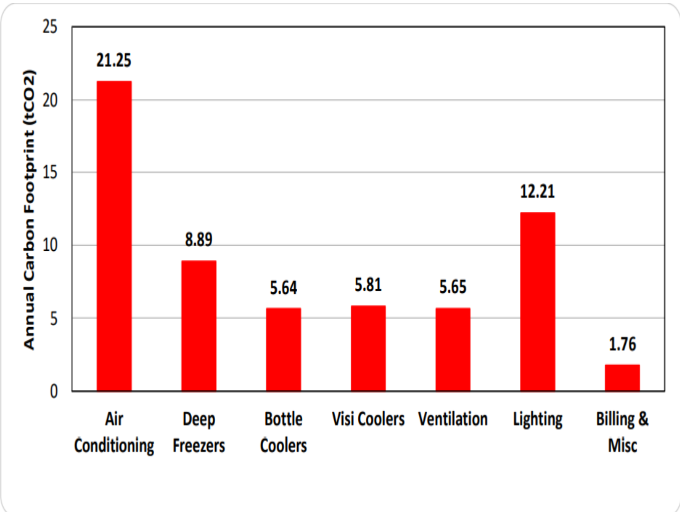

Chart -4: Annual Carbon Footprint from various equipment

5. RENEWABLE ENERGY UTILIZATION BY INSTALLING A SOLAR PV POWER PLANT

Energy harvested from sun is one of the cleanest forms of renewable energy available from nature. The roof top of the facility has a feasible space to install Solar PV Panels up to a capacity of 25.59 KWp. To offset the annual energy demand by 40%, it is recommended to install a 25.59 kWp grid tied solar PV power plant. This can offset the annual carbon footprint from electricity consumption by 21.49 tCO2.

Table -4: Energy savings calculations

Particulars	Value	Unit
Available Roof Space	166.3	m^2
Maximum feasible size of solar PV power plant	25.59	kWp
Monthly energy demand	6420	kWh
Annual energy demand	77040	kWh
Proposed capacity of solar PV required to offset annual energy demand by 40%	25.59	kWp
Annual energy yield	30708	kWh
Annual monetary savings @ Rs. 9.3 Rs/unit	285,584	INR
Investment @ 65,000/kWp	1,663,350	INR
Simple Pay Back Period	5.82	Years
Return Over Investment	17	%

6. ENERGY CONSERVATION POTENTIAL

The Strategy of adjusting and optimizing, 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 is Energy management. Energy management helps a facility to achieve and maintain optimum energy procurement and utilization, throughout the facility to minimize the energy costs without affecting the production and quality to minimize environmental impacts. Using less energy by incorporating energy efficiency or behavior change ideas, and attaining energy savings without affecting comfort or product quality is known as Energy Conservation. By incorporating the recommendations in the previous chapter, energy conservation is achieved.

Table -5: Energy saving potential of various equipment

	Annual Energy Consumed (kWh)		Annual Energy Saving Potential (kWh)
Equipment	**Baseline**	**Proposed**	
Air Conditioning	30353	30353	0.00
Deep Freezers	12651	9673	2978.40
Bottle Coolers	8026	4938	3087.90
Visi Coolers	8256	5880	2376.15
Ventilation	8056	4804	3252.00
Lighting	17425	17425	0.00
Billing & Misc	2471	2471	0.00
Total	**87239**	**75544**	**11694.45**

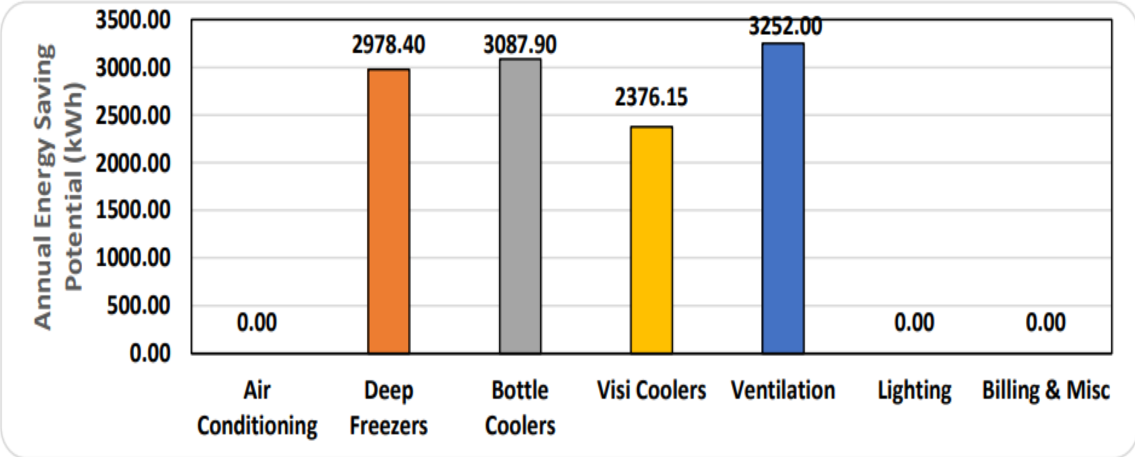

Chart -5: Energy saving potential of various equipment

Offsetting of Carbon footprints is possible through switching to Energy Efficiency, Renewable Energy and Circular Economy. The annual carbon footprint of the facility can be offset to 25 tCO_2/yr.

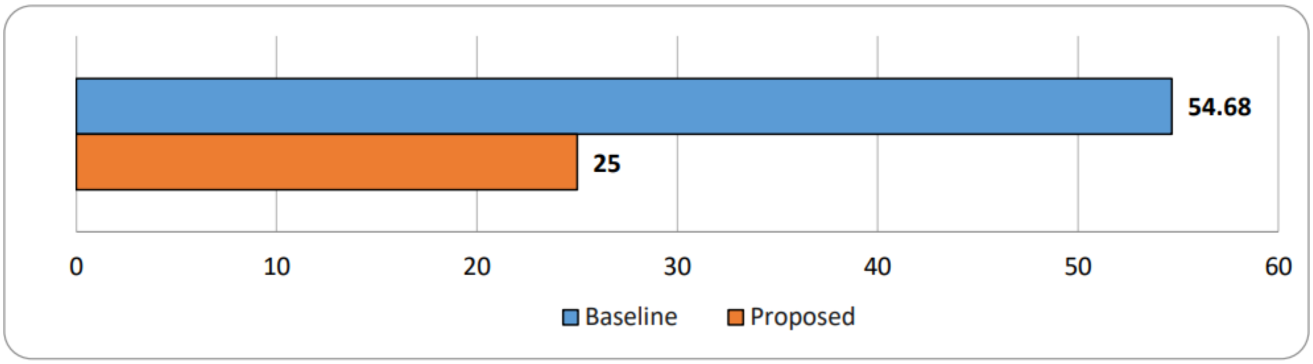

Chart -6: Annual Carbon offset potential

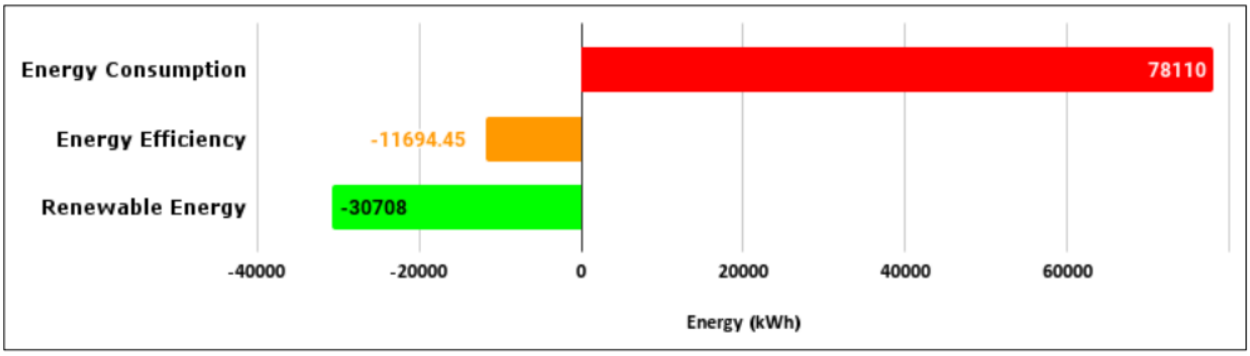

Chart -7: Statistics of Annual Energy offset Potential

7. ThermalImaging

Thermal imaging is an important parameter in energy auditing of any building. It is used to convert infrared (IR) radiation into viewable images that shows the distribution of temperature differences which is viewed by a thermal camera. It was carried out for different refrigeration systems and electrical wiring contacts. Overheating of compressor in deep freezers were detected as there no proper spacing for air flow. The below images show the thermal images of the deep freezers.

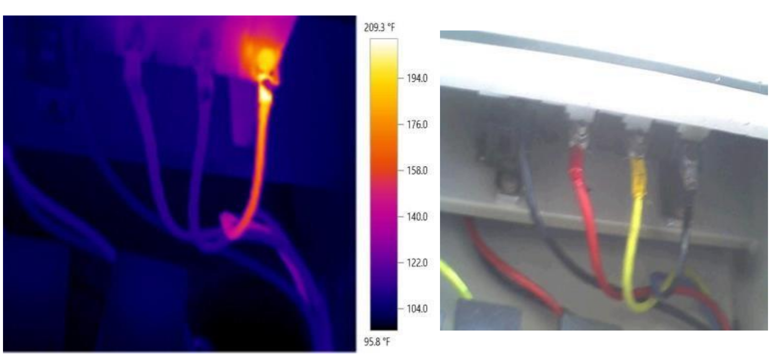

Fig -1: Thermal imaging of electrical wiring

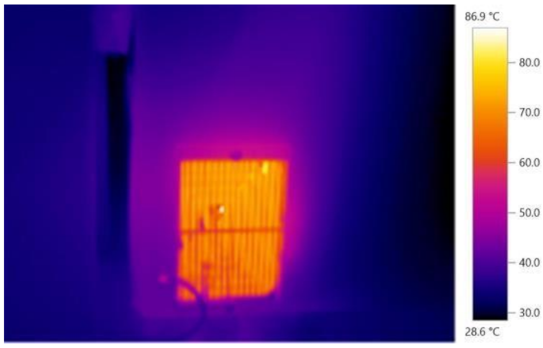

Fig -2: Thermal imaging of compressor

8. Graphical Representation using Power Logger

A power logger was used to log the 24-hour data of the equiment. HIOKI Power Logger was used to carry out the logging of 8 Deep Freezers, 3 Bottle Coolers, 4 Visi Coolers and an Open Cooler. The power logger is used to measure the Active Power, Reactive Power Energy, Power Factor etc. The 24-hour data is extrapolated into annual consumption by multiplying it by 365 days. The following waveforms show the active power and energy profile of different coolers.

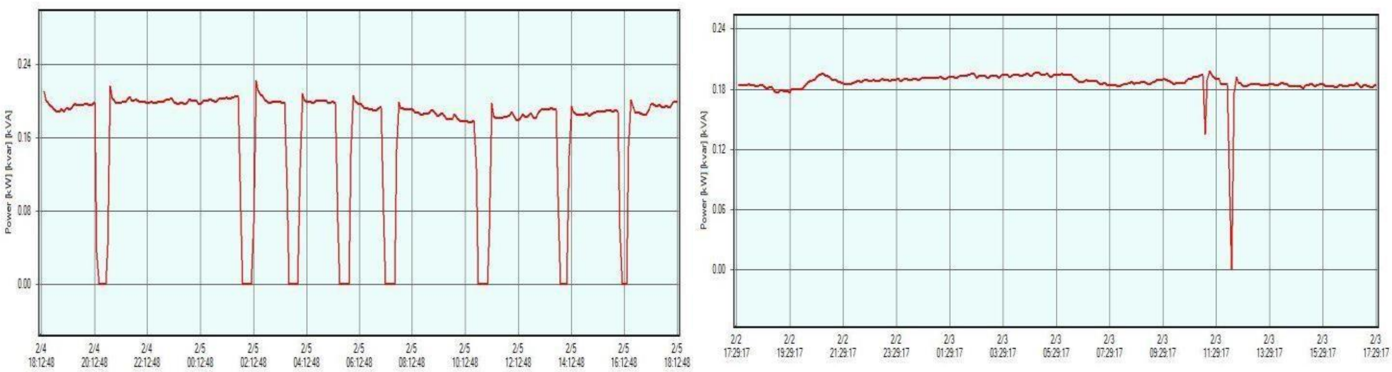

Fig -3: 24 Hours Active Power Profile (kVAR)

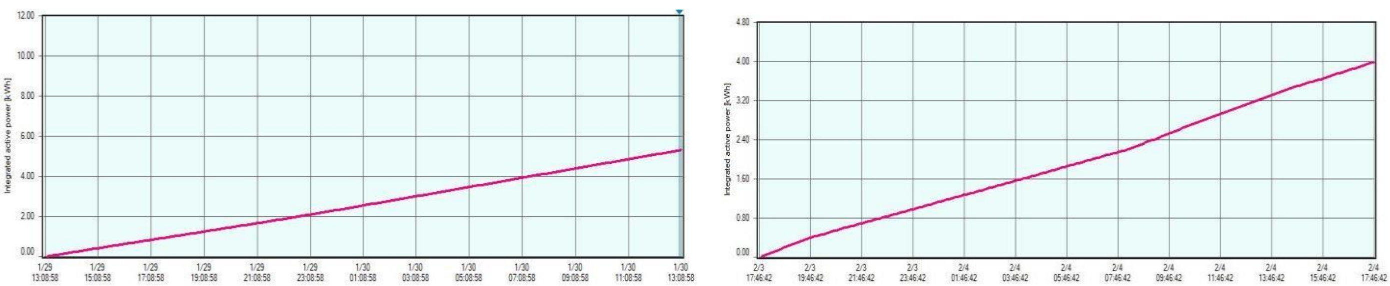

Fig -4: 424 Hours Energy (kWh) profile

9. CONCLUSION

An energy optimization study was carried out at a retail outlet in Kerala and many energy saving recommendations have been identified. From the detailed analysis of energy consumption of each equipment in the retail outlet, it was found that refrigeration and air conditioning system consume higher percentage of energy. The refrigeration systems in the retail outlet consume higher energy due to the improper practice of adjusting the temperature and thereby thermostat cut-off function will be inoperative. Therefore, by adjusting temperature setting and adding additional timers to its control, the equipment lifetime and overall energy savings can be improved. The total energy saving potential of the retail outlet was about 11694.45kWh and the by installation solar panel 30708 kWh power can be generated. Also, by saving the energy consumption the annual carbon footprint can be offset to 8.19tCO2.

This study helped to identify several measures to improve energy efficiency by using energy efficient equipment in large supermarket or retail outlets. The scope of this project is that with the use of 25.59kWp grid tied solar power plant installation there are provision for offsetting the annual energy demand by 40%.

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