Journal of Materials and Environmental Science
ISSN : 2028-2508
e-ISSN : 2737-890X
CODEN : JMESCN

J. Mater. Environ. Sci., 2025, Volume 16, Issue 8, Page 1457-1464

http://www.jmaterenvironsci.com

An Analysis of Sunti Golden Sugar Company's Energy Audit and Power Quality Enhancement in Mokwa Local Government Area, Niger State, Nigeria

Abubakar Muhammad[1,2], Madya Siti Maryam Binti Sharun[1], Muhammad Firdaus Asyraf bin Abdul Halim Yap[1], and Sumaila Abdulmumuni[3*]

[1]*Faculty of Innovative Design and Technology, Universiti Sultan Zainal Abidin Malaysia Kampus Gong Badak 21300 Kuala Terengganu, Terengganu Malaysia*

[2]*Department of Electrical Engineering Technology, Minna Institute of Technology and Innovation, Nigeria*

[3]*Department of Chemistry, Confluence University of Science and Technology Osara, Nigeria*

**Corresponding author, Email address: muminislam2012@gmail.com*

Received *13 Mar 2025,*
Revised *25 June 2025,*
Accepted *07July 2025*

Citation*:Abubakar Muhammad, Madya Siti Maryam Binti Sharun, Muhammad Firdaus Asyraf bin Abdul Halim Yap, and Sumaila Abdulmumuni (2025) A Study on the Energy Consumption and Power Quality at Sugar Production Industry in Nigeria, J. Mater. Environ. Sci., 16(8), 1457-1464*

Abstract: Developing countries like Nigeria have low consciousness on energy conservation and are faced with the problems of having to generate more energy rather than to make use of the existing energy efficiently. This study focuses on energy audit and power quality issues at Sunti Golden Sugar Company (SGSC), a developing country with low energy conservation consciousness. The company requires an average of 45.12kWh of energy to crush 1ton of sugarcane, exceeding the recommended standard of 35kWh. Harmonics in the power system cause overheating of motors, leading to motor burnout and false tripping of protective relays. The energy audit results show a difference of 12.12 kWh/ton of electrical energy intensity between benchmarks and SGSC's current usage. Proper replacement with energy-efficient premium motors resulted in energy savings of 71,605kWh/year and cost savings of ₦1,949,125.7016 per year, with payback years ranging from 1.83 to 5.74 years. The study also presents the design and simulation of Shunt Hybrid Power Filters (SHPF) to suppress current harmonics produced by non-linear loads in the factory.

Keywords: *Energy Audit; Power Quality Improvement; Sugar Industry; Sunti*

1. Introduction

Energy can be best described by what it can do; nevertheless, we cannot see energy, only its effect can be felt. It cannot be destroyed, but can be wasted or utilized inefficiently. Energy is needed to create goods from natural resources and to provide many of the services that have been taken for granted (Rogers and Mayhew, 2021; Dincer, 2021).

Energy analysis in a production company explains energy consumption and energy requirements at various stages of production and can be applied in making recommendations for improvement in design and performance of energy transfer systems (Tola *et al*., 2023). Energy audit can be performed in production processes of various products such as sugar, palm-kernel oil, rice, cashew nut, and sunflower oil. A product such as sugar is derived from sugarcane. There are three main types of sugarcane-processing plants: sugar factories, ethanol distilleries and integrated sugar and ethanol plants generating both products from sugarcane (Birkett, 2016; Ungureanu*et al.*, 2022; Marques *et al.*, 2024). In addition, sugar refineries exist to complete sugar-making processes. The refineries convert raw sugar obtained from sugar factories into a form that can be consumed by humans.

The global business environment is becoming more competitive, so manufacturers are looking for ways to cut manufacturing costs without compromising the quality and quantity of their production output (Attaran, 2017; Christina and Ernst, 2018). There is rising energy generation costs, increases costs of production and reduce value added at the plant in both public and private businesses, production output (De Loecker *et al.*, 2020). There is also the difficulty of sustaining the output of a high-quality product despite the reduction in production costs met by successful, cost-effective investment in energy efficiency technology and techniques (Chowdhury *et al.*, 2018). This is crucial, especially now that energy-efficient solutions frequently include side benefits like raising business productivity or lowering material use. (Rissman *et al.*, 2020). About 40% of the global commercial energy is often utilized by the industrial sector due to the availability of large energy consuming equipment like the Conveyors, water pumps, boilers, compressors, and other energy consuming (Gupta, 2018). The industrial sectors however, face numerous challenges in efficiently utilizing the energy they generate (Fang *et al.*, 2019). Lack of correct or sufficient knowledge on the idea of energy conservation has resulted in significant financial losses from energy costs, causes certain issues with the environment, and reduces industrial competition (Kirschen *et al.*, 2018 and Bhattacharyya*et al.*, 2017). The sugar industry is not excluded from these huge financial losses.

Energy consumption rates in sugar factories influence the cost of sugar production and illustrate the contribution of sugar factories to environmental pollution (Ibrahim and Workneh, 2023). For instance, inefficient utilization of steam and fossil fuel in sugar-refining process can lead to low refined sugar output, increase production cost, and contribute greatly to pollution through production of greenhouse gasses (Bhatia, Jha, Sarkar, and Sarangi, 2023). Pollution from sugar factories is a major environmental concern. Air pollution by combustion products (CO_2, N_2O, among others) are greenhouse gases (GHG) and lead to global warming with attendant negative consequences on agriculture, water supply, forest resources, sea level rise, and human health (Echendu, Okafor, and Iyiola, 2022).

The Sunti sugar industry or factory is actively involved in the production of raw sugar, fortified Sugar and Molasses. Sugar cane plant is the main input raw material. There are different units and heavy-duty machines and equipment that consumelot energy. The sugar industry is among the most important sectors of the global economy considering the growing demand for Sugar Globally (Reid, 2016). A typical structure for the sugar business has sub-sections that are inhabited by a variety of distinct units operating independently (Kwenda, 2015). The building may yet include some undiscovered flaws that could result in energy usage that is needless (Tuysuz *et al.*, 2017). As a result of this there is the need to audit the energy usage in Sunti Golden Sugar Company for power quality improvement in Mokwa Local Government of Niger State, Nigeria

Manufacturing sectors are considered the backbone of development in general and economic development in particular. The importance of industrial development in eradicating unemployment and poverty in any nation cannot be over emphasized. Countries that transform their raw materials into finished goods of higher value are always prosperous and the expansion of a country's manufacturing industries is used to gauge its economic strength (Salmeron and Litran, 2014). To remain competitive in the global market, such a nation must ensure that her products are of the highest quality. In ensuring that manufacturing industries in any nation meet up with their production targets, energy generation and utilization is a key factor in factory operations since all production activities involve the use of energy (Harjit, 2006).

Sugar factories are the most energy-consuming industrial sub-sector globally. Almost 29% energy of the food, beverage and tobacco sector is consumed by the Sugar production factories (Akinyemi and Oladunjoye 2021;Malik and Hu, 2022; Szymańska and Mroczek, 2023). Sugar mill efficiency is a key consideration as it can directly affect the selling price of sugar on the domestic market. Sunti Golden Sugar Company Daily Energy consumption is approximately 72,464kWh, and monthly consumption is approximately 2,173,920kWh. From the recorded data, 45.12kWh of energy is consumed to crush 1 Ton of cane instead of 32kWh to 33kWh of energy which is the standard (Mahdi, 2018). It is clear that Sunti Energy Consumption Status is not efficient due to losses and wasteful use of electrical energy that could have been used productively, hence the need for Energy Audit and Power Quality Improvement of Sunti Golden Sugar Company (SGSC). The most significant problem at SUNTI Sugar Company is the harmonics. The electric motors get heated consecutively and this leads the motors to burn out. And the company is also faced with problems of false tripping of protective relays that causes unnecessary down time in company’s production process. The aim of this study is to develop a systematic approach and carry out energy audit of Sunti Golden Sugar Company, thereby improving Power Quality (PQ).

2. Methodology

A systematic technique will be used to gather pertinent information regarding the factory's energy utilization performance. The first step involves a visual inspection and collecting available energy data. This preliminary energy audit (PEA) helps identify significant energy consuming systems that can be evaluated with portable instrumentation systems during the detailed energy audit (DEA). As part of a thorough energy audit, each of these significant energy-consuming systems will be put to the test to determine relative energy efficiency and cost reduction potential. The interviewing of plant staff to ascertain schedules, operating specifics, and procedures is a crucial step in the energy audit process.

The necessary data was collected from different sources in the factory. Several operations/processes in the factory consume energy. The following are the main energy sources used in the factory. Electricity, Bagasse Fuel, Diesel oil, Steam, Water, Compressed Air. Raw materials in the form of sugar cane plant from the field is brought to the weigh bridge via carts to be weigh and then conveyed to cane yard of 3000 TCD capacity. Several major systems and processes in the factory consume energy. Electrical power enters into the SGSE plant directly from the generating station of 11kV high voltage output line. Lighting in the plant is delivered primarily by 5-foot fluorescent tubes mounted two per fitting. The florescent tubes are of standard wattage. A typical sugar industry has electric motors ranging from few kW to a few MW. The three phase induction motors are the most widely used electric motors in the industry. Electric motor efficiency is the ratio of the mechanical power output to its electrical power input. Electric motors convert electrical energy to mechanical energy to achieve useful work. While performing this task, some of its energy is being loss. Operating costs of an existing standard motor can be connected with that of an appropriately sized energy efficient replacement, when the operating hours, efficiency enhancement values, and loads are determined. This technique employs the use of hand held measuring instruments to obtain the data. In this thesis on energy auditing and efficiency improvement at the factory, the data collection has been done through different methods such as personal interviews, direct observation of the factory equipment, by taking measurements, telephone communication, and the available documents from each section of the factory.

3. Results and Discussion

Table 1 and Figure1briefly summary about the lighting system of the factory is presented with a total number of 971 Fluorescent lamps. The installed capacity of the existing lamps is 50.316kW with a daily energy consumption of 805.056kWh. From the table, it can be seen that the actual lamps required in the factory is calculated and found out to be 839 florescent lamps. It is very clear that the number of unnecessary lamps that constitute waste of energy in the factory is 132 lamps. Total Energy Utilized (EU) by the existing system is calculate and found out be 744.936kWh and also, the Total Energy Required (ER) by the factory is calculated and found out be 656.992kWh which shows or indicate potential energy efficiency improvement within the lighting system of the factory. The Energy Difference (ED) also proves that there are significant losses of energy within the factory's lighting system.

Table 1. Lighting data of the factory

No.	Section	NL	TP (Watt)	TLu, (Lumen)	RA, (m2)	ILu (Lux)	ALR	OH	EU(kWh)	ER(kWh)	ED(KWh/day)
1	Security posts	6	216	18360	75	244.8	3	24	5.184	2.592	2.592
2	Laboratory	15	540	45,900	95	483.2	9	14	7.56	4.536	3.024
3	Workshop	60	2160	183600	150	1,224	34	14	30.24	17.136	13.000
4	Store	60	2160	183600	150	1,224	34	16	34.56	19.584	14.976
5	Admin Office	40	1440	122400	210	582.9	32	16	23.04	18.432	4.608
6	Power house	25	900	76500	75	1020	18	24	21.6	15.552	6.048
7	Cane yard	38	1368	116280	95	1224	34	16	21.888	19.584	2.304
8	Mill house	70	4200	357000	400	892.5	65	14	58.8	54.6	4.200
9	Boiler section	200	12,000	1,020,000	1200	850	190	14	168	159.6	8.400
10	Ware house	80	4,800	408,000	500	816	74	14	67.2	62.16	5.040
11	Process house	250	15,000	1,275,000	1400	910.71	235	14	210	197.4	12.600
12	Waste water treatment plant	40	2400	204,000	300	680	35	19	45.6	39.9	5.700
13	Bagasse yard	38	1368	116,280	200	581.4	33	14	19.152	16.632	2.520
14	Portable water	14	504	42840	80	535.5	9	19	9.576	6.156	3.420
15	Air Compressor	6	216	18360	40	459	4	14	3.024	2.016	1.008
16	Chemical store	8	144	12240	70	174.9	5	24	6.912	4.32	2.592
17	Weigh bridge	25	900	76500	90	850	22	14	12.6	18.088	1.512
	Total	971	50316				839		744.936	656.992	94.838

Figure 2 and Table 2shows the result obtained from Motor master + international software result of replacing standard motor with energy efficient motor which also show the amount of energy saved in kWh/year and the corresponding cost saving in euro per year (71,605kWh/year and ₦1,949,125.7016/year). It is significant to replace large, partially loaded motors with smaller, fully loaded motors made of company stock or brand-new, energy-efficient motors. As a result, replacing ordinary motors with energy-efficient motors, i.e., replacing under-load motors with properly sized motors can result in annual savings of 71,605kWh of energy and ₦1,949,125.7016 with payback times ranging from 1.17 to 5.74 years.

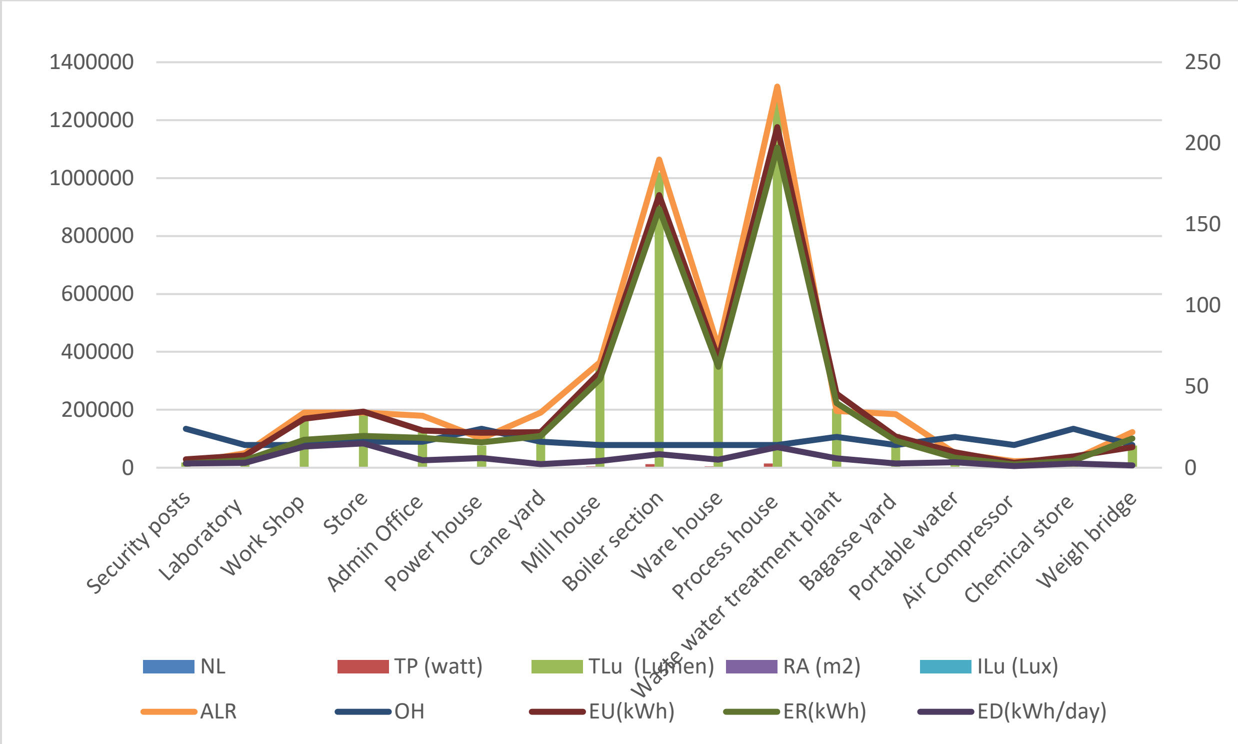

Figure 1: Lighting data of the factory.

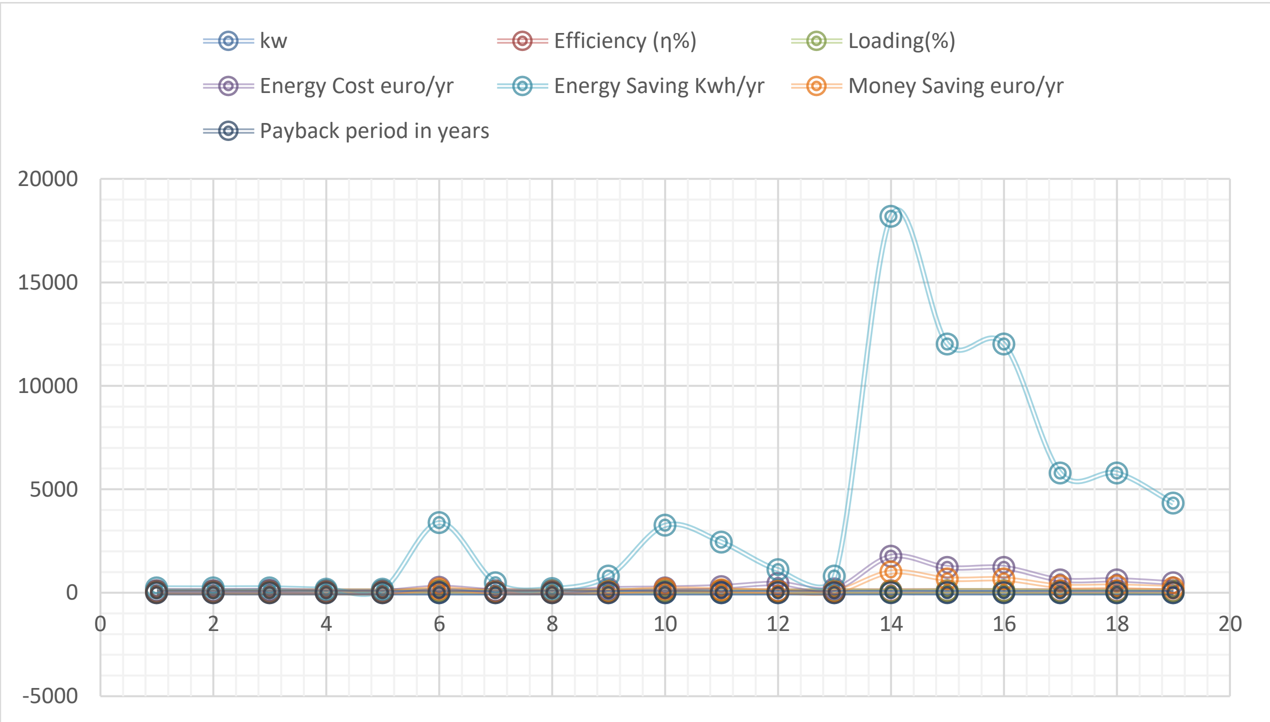

Figure 2: Energy Efficient Motors

Table 2. Energy Efficient Motors

No.	Motor's name	Power kw	Efficiency (η%)	Loading (%)	Energy Cost euro/yr	Energy Saving Kwh/yr	Money Saving euro/yr	Payback period in years
1	Surplus belt conveyor	0.55	71.2	77.5	96	231	13	5.74
2	Ash Inertial Rotary	0.55	71.2	77.5	96	227	12	5.85
3	Back wash pump	1.5	85.2	80	105	231	13	5.74
4	Rotary valve feed silo	0.3	85.2	75.5	56	167	9	4.24
5	Phosphate dosing	0.3	85.2	75.7	56	165	9	4.28
6	ACOP Motor (x2)	1.5	88.3	92	259	3382	186	1.76
7	EOT CT	0.55	99	65.5	83	485	27	2.73
8	Lime bin rotary valve (x2)	0.25	86.1	72	44	203	11	5.72
9	GVC Motor (x2)	0.9	82.2	98.8	187	804	44	2.1
10	Barring gear Motor	4	98.7	77.6	225	3257	179	1.83
11	PH dosing pump (x2)	2.2	92.7	86.5	296	2444	134	2.89
12	SMBC (X2)	3.7	88.6	66.9	447	1106	61	4.58
13	Vacuum filters (x2)	1.1	84.1	91.2	191	801	44	5.12
14	Service water pumps (x3)	15	91.9	67.3	1758	18186	1000	1.29
15	C-Mascuite Liquid	7.5	95.6	92	1218	12012	661	1.28
16	B-Masuite Tr. Motor	7.5	95.6	92	1218	12012	661	1.28
17	Flash tank Recirculation (x2)	5.5	91.2	63	622	5780	318	2.12
18	Mill ACW fan	5.5	91.2	63	622	5780	318	2.12
19	Ash silo	3.7	98.8	71.1	474	4332	238	1.17
	TOTAL					71,605.00	€3,938.00	

Conclusion

The SGSC paid little attention to monitoring the factory's energy use and efficiency. The inference is that energy is being wasted because people are using it inefficiently. They might use this study to analyze their energy usage and efficiency trends, particularly with regard to their lighting system, air compressor, and boiler. Moreover, they can use the software Motor Master + International on their electric motors, which constitute the majority. The program aids in locating possibilities to increase system efficiency through energy use. A detailed energy audit has been analyzed. Based on the losses energy efficiency assessments on the major energy equipment's like electric motors, air compressors, boilers, and lightings have been done. It has been found from energy audit results that an annual Energy loss from both compressors can be calculated which is 98,840kWh/year which is equivalent in Naira as #3,558,240. Using motor master+ international software as shown in Figure 1, It has been observed that switching from a 4 kW pump motor to an energy-efficient 1.5 kW pump motor can result in energy savings of 3,257 kWh per year and financial savings of 179 euros per year with payback times of 1.83 years. Additionally, replacing a normal motor with an energy-efficient motor results in a 71,605 kWh/year with energy savings of €3,938/year cost savings. It is significant to replace large, partially loaded motors with smaller, fully loaded motors made of company stock or brand-new, energy-efficient motors. As a result, replacing ordinary motors with energy-efficient motors, that is., replacing under-load motors with properly sized motors, can result in annual savings of 76,474 kWh of energy and €4,205, with payback times ranging from 1.17 to 5.85 years. The study also presents the design and simulation of shunt hybrid power filter for the electric drive system. The filter is tested and verified using MATLAB Simulink environment with two type of nonlinear load system CSI and VSI. The comparative analysis show that harmonic is mitigated from 20.42 % to 7.33 % for supply current and 24.31% to 7.44% for load current with P-I based SHPF for CSI type nonlinear load and harmonic is mitigated from 17.99 % to 6.6% for supply current and 20.20% to 9.62% for load current in the VSI type nonlinear load.

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest.
Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

References

Akinyemi, O. O. & Oladunjoye, O. A. (2021). Energy Performance Modeling of a Sugar Manufacturing Industry. *Journal of Pure and Applied Sciences*, 7, 3, 155 – 164, https://dx.doi.org/10.4314/dujopas.v7i3b.17.

Attaran, M. (2017). The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing. *Business horizons*, *60*(5), 677-688.

Bhatia, L., Jha, H., Sarkar, T., & Sarangi, P. K. (2023). Food Waste Utilization for Reducing Carbon Footprints towards Sustainable and Cleaner Environment: A Review. *International journal of environmental research and public health*, *20*(3), 2318. https://doi.org/10.3390/ijerph20032318.

Bhattacharyya S., Myrzik J., Cobben S. & Van Casteren J. (2017). Harmonic Current Interaction at a Low Voltage Customer"s Installation", presented at the 10th *International conference on Electrical Power Quality and Utilization*, Lodz, Poland.

Birkett, H.S. (2016). The efficiency of the steam generating plant in the cane sugar factory. Proc. B.W.I. Sugar Tech., 2, 352-362.

Chowdhury, J. I., Hu, Y., Haltas, I., Balta-Ozkan, N. and Varga, L. (2018). Reducing industrial energy demand in the UK: A review of energy efficiency technologies and energy saving potential in selected sectors. *Renewable and Sustainable Energy Reviews*, *94*, 1153-1178.

Christina G. & Ernst W. (2018). Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry, an Energy Star Guide for Energy and Plant Managers, March 2018.

De Loecker, J., Eeckhout, J. and Unger, G. (2021). The rise of market power and the macroeconomic implications. *The Quarterly Journal of Economics*, *135*(2), 561-644.

Dincer, I. & Rosen, M.A.(2017). Energy environment and sustainable development. Canada: UOIT.

Echendu, A. J., Okafor, H. F., &Iyiola, O. (2022). Air Pollution, Climate Change and Ecosystem Health in the Niger Delta. *Social Sciences*, *11*(11), 525. https://doi.org/10.3390/socsci11110525.

Fang, D., Zhao, C. and Kleit, A. N. (2019). The impact of the under enforcement of RPS in China: An evolutionary approach. *Energy Policy*, *135*, 111021.

Gupta J. (2018). Electrical Energy Audit of induction motors in textile plant, Thapar university.

Harjit S.B. (2006). Power Quality Analysis Using Relay Recorded Data.

Ibrahim T.S.T., Workneh T.S. (2023) The environmental impact of the sugar industry waste in Sudan, *Environmental monitoring and assessment*, *195*(7), 870. https://doi.org/10.1007/s10661-023-11401-8.

Kirschen, D. S. and Strbac, G. (2018). *Fundamentals of power system economics*. John Wiley & Sons.

Kwenda, P. R. (2015). A review of the sugar milling process in South Africa and how it influences the length of the milling season. *MSc Bio-resources Systems. University of KwaZulu-Natal, School of Engineering*.

Mahdi, A. M. (2018). Energy Audit a step to effective Energy Management. International Journal of Trend in Research and Development, 5(2), 521-525.

Malik, V. S., & Hu, F. B. (2022). The role of sugar-sweetened beverages in the global epidemics of obesity and chronic diseases. *Nature reviews. Endocrinology*, *18*(4), 205–218. https://doi.org/10.1038/s41574-021-00627-6.

Marques J.C., Gasi F., Lourenço S.R. (2024). Biofuel in the Automotive Sector: Viability of Sugarcane Ethanol. *Sustainability*. 16(7), 2674. https://doi.org/10.3390/su16072674

Reid, W.E. (2016) 'Power quality issues-standards and guidelines', IEEE Trans. Ind. Appl.,2016, 32, (3), pp. 625–632.

Rissman, J., Bataille, C., Masanet, E., Aden, N., Morrow III, W. R., Zhou, N. and Helseth, J. (2020). Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070. *Applied Energy*, *266*, 114848.

Rogers, G. & Mayhew, Y. (2021). Engineering Thermodynamics, 4th Edition. IndiaAddison Wesley Longman, Indian Branch.

Salmeron, P. &Litran, S. P. (2014). Reference voltage optimization of a hybrid filter for nonlinear load compensation," IEEE Trans. Indust. Electron., June 2014 , vol. 61, no. 6.

Szymańska, E. J., &Mroczek, R. (2023). Energy Intensity of Food Industry Production in Poland in the Process of Energy Transformation. *Energies*, *16*(4), 1843. https://doi.org/10.3390/en16041843.

Tuysuz, M. F., Ankarali, Z. K. and Gözüpek, D. (2017). A survey on energy efficiency in software defined networks. *Computer Networks*, *113*, 188-204.

Ungureanu N., Vlăduț V., Biriș S-Ș. (2022). Sustainable valorization of waste and by-Products from Sugarcane Processing. *Sustainability*. 14(17), 11089. https://doi.org/10.3390/su141711089

(2025) ; http://www.jmaterenvironsci.com