

ELECTRICAL ENERGY MANAGEMENT AND CONSERVATION OPPORTUNITIES IN BHILWARA TEXTILE INDUSTRY

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Available online at: www.sijmr.org

Received: 12-09-2025, Accepted: 24-09-2025, Online: 30-09-2025

Abstract— Energy is a major cost driver in the textile industry, making efficiency crucial amid rising price volatility. This study examines energy usage and management practices in Bhilwara textile plants through detailed audits of processes and energy-intensive equipment such as motors, drives, and lighting systems. Case studies with savings and cost data illustrate current consumption patterns, losses, and opportunities for improvement. By adopting energy-efficient technologies, optimizing operations, and implementing targeted measures, textile plants can achieve lower costs, improved performance, and a more sustainable footprint.

Keywords— Specific Energy Consumption, Energy Management, Energy-Saving Opportunities, Energy Performance, Operational Efficiency

I. INTRODUCTION

The textile industry is one of the most significant sectors globally, yet many plants struggle with inefficiencies arising from inadequate planning and a fragmented structure of independent subsectors. This often results in hidden energy wastage and unnecessary consumption. Studies have consistently shown the sector's strong potential for energy savings; as early as 1988, the finished textile sector was estimated to reduce process heat by 16% and power use by 8% with existing technologies [1]. The industrial sector overall consumes about 40% of commercial energy, with both electrical and thermal energy heavily used in equipment such as pumps, boilers, and compressors. However, limited awareness of energy conservation continues to drive up costs, harm the environment, and weaken competitiveness [2]. While most assessments have emphasized thermal energy, electrical energy plays an equally critical role in industrial efficiency and performance [3].

In today's competitive global market, rising energy prices have heightened the urgency for manufacturers to reduce production costs without compromising yield or quality. Energy-efficient technologies and practices not only cut operating costs but also enhance productivity, reduce material and water use, and improve environmental sustainability [4]. Importantly, energy efficiency is not about restricting energy use but about eliminating waste—maintaining production levels while lowering consumption and costs. The ultimate goal is to enhance profitability while building a more sustainable industry [5].

II. RELATED WORK

Many industrial sectors face challenges in using energy efficiently. As a result, they incur higher energy costs, contribute to environmental problems, and risk losing competitiveness. Some of the key factors leading to inefficient energy use are listed below:

The efficiency of much industrial equipment and processing often falls below expected levels. This is primarily due to insufficient maintenance, delayed replacement of outdated equipment, and inadequate process control.

Poor Design and Improper Installation: Excessive energy consumption often results from inefficient equipment, irrational energy use, and a lack of awareness or knowledge about energy conservation practices.

The rising cost of energy sources, such as coal, leads to higher operational expenses for factories and contributes to environmental pollution.

One major challenge in the textile industry is the use of outdated machinery and equipment. Many machines have been in operation for several decades and have not received consistent or effective maintenance over time. A common issue faced by these enterprises is the shortage of spare parts and accessories, which prevents timely maintenance and replacement of worn or damaged components. Due to limited domestic supply, most of the necessary parts and spares must be imported, further complicating maintenance efforts.

This study addresses energy challenges in textile factories, from resource use to key equipment including motors, drives, spindles, looms, knitting and sewing machines, and air compressors. It also proposes effective solutions aimed at improving the efficiency of energy use across these systems.

III. METHODOLOGY

This paper examines and evaluates current energy use and management practices in textile manufacturing processes in the Bhilwara region. It focuses on identifying opportunities to improve the energy performance of these plants. Study Area (Textile Mill in Bhilwara): The factory, primarily designed to produce polyester and cotton yarn, is one of the most modern textile mills in the country. It features state-of-the-art technology and equipment for yarn manufacturing.

The factory is equipped with advanced spinning technology, including open-end spinning. The pre-spinning stages, such as second-pass drawing and roving, as well as the post-spinning stage of winding, can all be performed at a single location. The plant also houses knitting machines

for fabric production. Additional modern features include a state-of-the-art air conditioning system, a fully equipped physical testing laboratory, an efficient water treatment plant, a comprehensive fire fighting and safety system, and well-organized mechanical, electrical, and automotive workshops.

IV. DATA COLLECTIONS

In this research on industrial energy auditing and efficiency improvement at the textile factory, data was collected using multiple methods, including face-to-face interviews, direct observation of the facility, telephone discussions, questionnaires, and review of the company’s available documents.

The following tables present three years of data on the factory’s textile production and energy consumption. They also show specific energy consumption, annual energy costs, total plant energy expenses, and benchmark comparisons with standard plants.

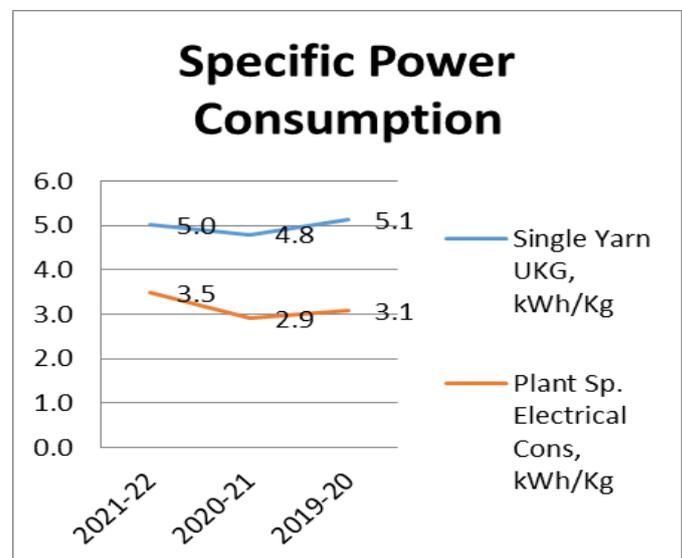
Table 1: Assessment of Production and Energy Efficiency in Textile Plants

Items	Unit	Years	Year	Year
		2021-22	2020-21	2019-20
Yarn Production (40's Count)	Tonne	14021	11516	13532
TFO	Tonne	3957	5100	7537
Open End Production (10's Count)	Tonne	6578	4828	7017
Knitting Production	Tonne	2712	2756	2701.62
Total Production	Tonne	27267	24200	30787
Total Electric Consumption	kWh	94827611	70645262	95096810
Yarn Power Consumption	kWh	70373929	55273815	69367449
Single Yarn UKG	kWh/Kg	5.02	4.80	5.13
Plant Sp. Electrical Cons	kWh/Kg	3.48	2.92	3.09
Energy Intensity (Elec)	GJ/Tonne	12.52	10.51	11.12

SITRA has developed standard procedure for calculating a spinning mill’s 40s converted Ukg using conversion factors and 4.10 Ukg in the present standard for single yarn production. Best mills are able to achieve a 40s adjusted Ukg below 3.8.

V. ENERGY LOSES ASSESSMENT

Assessment of Plant Energy Consumption Intensity: Energy intensity refers to the amount of energy used to produce a unit of product and serves as an indicator of a plant’s energy efficiency. The following graphs illustrate the energy intensity of the selected textile factory from 2019 to 2022, alongside the energy intensity of benchmark textile plants. The graphs also compare the specific energy consumption of the selected plant with that of the benchmark facilities. It is evident from the comparison that the benchmark plants demonstrate higher energy efficiency than the selected textile factory.



Specific energy consumption per kg of product is around 5 kWh/kg which is higher side from industry best 3.8 kWh/kg

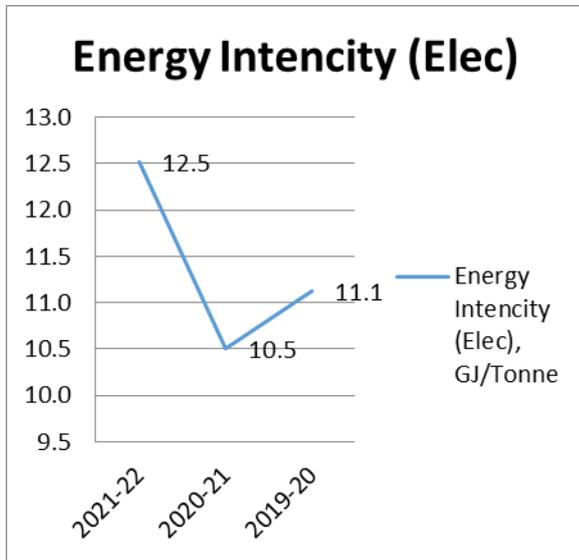


Figure 1: Specific Energy Consumption and Plant Energy Intensity

The annual specific electrical energy intensity of the plant for the fiscal years 2019 to 2021 ranges from 10.51 GJ/tonne to 12.52 GJ/tonne. For yarn production, the average specific electrical energy consumption is 4.98 kWh/kg. The total electrical energy intensity of the plant is illustrated in Figure 1, as per SITRA standard procedure for calculating a spinning mill’s 40s converted Ukg using conversion factors and 4.10 Ukg in the present standard for single yarn production. Thus, there is a difference of 0.88 kWh/kg between the benchmark standard and the actual consumption at the selected plant.

a) Explanation of Results

The analysis of the plant’s energy intensity reveals a gap between its electrical energy intensity and that of the selected benchmark. This indicates that there is significant potential to improve the plant’s energy efficiency. The following calculations illustrate the amount the company is spending on energy that could be saved with more efficient practices.

Annual Average production of Yarn 14021000 Kg per year.

Cost of electricity (R) = Rs. 7 per/kWh. Difference in electricity energy intensity = 0.88 Kwh/Kg

Cost Impact of Inefficient Electrical Energy Use Per Year = electric consumption in KWH * cost of Electricity.

= energy int (KWH / Kg) * production (kg) * cost of electricity (Rs. / KWH)

= Rs. 863 Lakh per year.

A significant financial saving of ₹8.63 crore per year could be achieved by improving electrical energy efficiency to match the benchmark specific energy consumption

VI. TEXTILE PROCESS-WISE ENERGY USAGE BREAKDOWN

The breakdown of electrical energy is based on the proportion of energy consumed by different sections of the plant. In these various sections of the textile industry, electricity is used for production processes, lighting, cooling towers, and other operational needs.

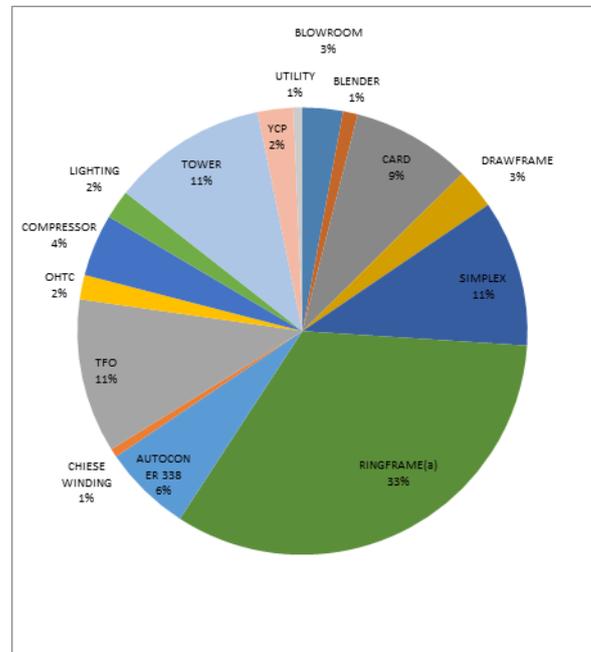


Figure 2: Spinning Plant: Distribution of Final Energy Consumption

From the figure above, it is evident that the Ring Frame is the highest energy-consuming machine, followed by the TFO and the humidification tower. Lighting also accounts for approximately 2% of the total energy consumption.

VII. KEY SOURCES OF ENERGY LOSS AND POTENTIAL EFFICIENCY IMPROVEMENTS IN TEXTILE PLANT

Based on the walk-through audit conducted at the plant and information gathered from collected data, the major electricity-consuming areas with significant potential for energy savings include lighting systems, ring frame operations, rewind motors, electrical distribution networks, air conditioners, and air compressors.

Energy efficiency improvements in the textile industry involve reducing the energy required to provide a specific service. This reduction is not always linked to technical changes alone; it can also result from better organizational practices, improved management, or enhanced economic efficiency, such as overall productivity gains. Energy efficiency primarily depends on the behavior and decision-making of individual energy users. Avoiding unnecessary energy consumption and selecting the most appropriate equipment helps reduce energy costs without compromising production or individual welfare. These actions not only improve efficiency at the plant level but

also contribute to enhancing the overall energy efficiency of the national economy [8].

A. Energy Saving by Optimizing Autoconer Suction Blower Frequency

During the study we have observed that Autoconer is consuming around 6% of total electrical energy demand and the main energy consuming part of autoconer is suction blower.

We have studied a/c suction blower pressure setting at a/c machine. Suction blower set frequency has been tabulated below:

Table 2: Energy Saving by Optimizing Autoconer Suction Blower Frequency

Autoconer Number	Pr. (mbar)	Set Pressure
1	53	55
2	45	38
3	45	38
4	45	38
5	49	38
6	47	38
7	44	38
8	45	38
9	48	40
10	55	40
11	45	40
12	56	35
13	51	42
14	47	40
15	55	42
16	40	38
17	41	38
18	46	38
19	50	38
20	44	38
21	55	38
22	40	30
23	40	33
24	40	28
25	45	45
26	40	40
27	40	45
28	58	65
29	40	50
30	40	50
31	52	50
32	51	50
33	53	50
34	54	50

Autoconer Number	Pr. (mbar)	Set Pressure
35	45	45
36	47	30
37	43	30
38	49	30
39	45	30
40	45	30
41	48	30
42	48	30
43	43	30
44	43	30
45	46	30
46	45	30
47	47	30
48	44	30
49	44	30
50	43	30
51	45	30
52	44	30
53	44	30
54	45	30
55	37	25

Some suction blower’s suction pressure is higher than the plant benchmark pressure as plant is running at 35 mbar pressure also. *At present maximum pressure is 50 mbar.* In some A/c Pressure setting was found 35mbar and in other Machines setting was found 38-40 mbar so it is suggested for pressure setting at 35 mbar. Power saving calculation has been tabulated below.

Table 3: Energy Saving by Optimizing Autoconer Suction Blower Pressure

S.N.	Particulars	Value
1	Present Average Running Pressure at A/c	46
2	Proposed Maximum Frequency of A/c Blower	35.00
3	Present Average Power Consumption	7.80
4	Proposed Average Power Consumption at 35 Pressure Setting	6.40
5	Energy Saving per Blower after Reduction of Frequency, kW	1.40
6	Total No. of Machine in	54
7	Plant Running Hr	8640
8	Estimated Energy Saving, kWh	653184
9	Avg Power Cost Rs/kW	6.7
10	Annual Saving, Rs. Lakh	43.76
11	Estimated Investment, Rs. Lakh	Nil
12	Simple Payback Period, Months	Immediate

By implementing this plant can save 653184 kWh and Rs. 43.76 Lakh per annum without any investment.

A. Energy Saving by Reduction of Cleaning Air Compressed Air Pressure at Spinning Plant

During study we have observed that one compressor were installed in spinning plant for catering compressed air requirement of cleaning of spinning machines operating Pressure is tabulated below.

Table 4: Spinning Machines Operating Pressure

S.N.	Description	Unit	Cleaning Compressor
1	Load Pressure	kg/cm ² g	6.8
2	Unload Pressure	kg/cm ² g	7.2

Average running pressure 7.0 kg/cm², other Spinning plant are running cleaning air compressors below 5 kg pressure. So it is suggested to reduce to the average unload pressure from 7.0 level to 5.0 level. Energy saving calculation has been tabulated below.

Table 5: Energy Saving by Reduction of Cleaning Compressed Air Pressure at Spinning Plant (Mill-21)

S. N.	Particulars	Values
1	Normal Air Pressure of Compressor, kg/cm ² , P1	7.15
2	Power Drawn by the Compressor, Power1	27.0
3	Actual I/L Air Pressure of Compressor, kg/cm ² , P2	5
4	Power Drawn by the Compressor at normal kg/cm ² , Power2 = $(P2^{(1.4-1)/1.4} - 1 / P1^{(1.4-1)/1.4} - 1) * Power1$	20.90
5	Energy Saving in kW	6.1
6	Annual Running Hours	3000
7	Estimated Annual Energy Saving in kWh	18301
8	Avg. Cost of Power, Rs. Per kWh	6.70
9	Annual Saving, Rs. Lakh	1.23
10	Investment, Rs. Lakh	Nil
11	Payback Period in Months	Immediate

By implementing this plant can save 18301 kWh and Rs. 1.23 Lakh per annum without any investment.

B. Energy Saving by Automation of H-Plant

During the study, study team check performance of H-Plant and found that H-Plants are consuming around 11% of Total electricity consumption so it is a major target area. We found that all H-Plants are operating at Manual and loading of all motors are coming more than 70%. In present time all new plants are using Automation of H-Plant which includes VFD at all Fans and Automatic damper control with humidity.



Figure 3: Automation of H-Plant

Which any lead to give around 8-10% of Power saving in all H-Plants. During present time H-plant is consuming around 10431037 KWh per year if we assume 8% of power saving plant can save 834482 kWh @ Rs. 6.7 Per kWh, plant can save Rs.55.91 Lakh per annum with investment of Rs. 150 Lakh in Automation of all H-Plants with 32 months payback period.

C. Enhancing Energy Efficiency in Electric Motor Systems

When aiming to enhance the efficiency of a motor system in an industrial setting, a holistic approach that includes the Ring Frame main motor, pumps, compressors, and fans should be adopted to achieve optimal energy savings and performance. Key considerations regarding energy use and potential energy-saving opportunities within motor systems are discussed below.

a) Monitoring, Control, and Optimization of Electric Motors

Implementing monitoring and management systems for electric motors is essential to maximize energy-saving opportunities.

- Make an inventory of motor systems, this will provide a clear framework for identifying and prioritizing actions and also give history of each motor, which is useful for deciding whether to repair or replace when problems occur.
- Measure the power consumed by each motor a ‘hoursrun’ meter, a clamp-on ammeter, and a portable power logging device, as well as permanent kilowatt-hour metering.
- Analyze and monitor the condition of each motor component to anticipate potential failures using techniques such as vibration analysis, oil analysis, and thermography surveys.
- Establish a motor survey and tracking program to maintain detailed records.
- Develop guidelines to support proactive decisions regarding repairs or replacements.
- Prepare for motor maintenance by maintaining an adequate spare parts inventory.

- Create clear purchasing specifications for motors and related components.
- Develop repair specifications to ensure consistent maintenance standards.
- Implement a predictive and preventive maintenance program to optimize motor performance and longevity.

b) Replacement of Low-Efficiency Motors with High-Efficiency Motors

Replacing a standard motor with a high-efficiency model may involve an additional capital cost of around 20–30%, but this is typically offset quickly by reduced operating expenses. Higher-efficiency motors require less input power (kW) to deliver the same mechanical shaft load. Even small efficiency gains can be economically beneficial for equipment that operates thousands of hours per year, and upgrading an existing motor to a premium-efficiency model often results in a short payback period. For instance, evaluating the 55 kW Ring Frame main drive motor at the plant against a high-efficiency motor model using the Motor Master Plus software yields the following results.

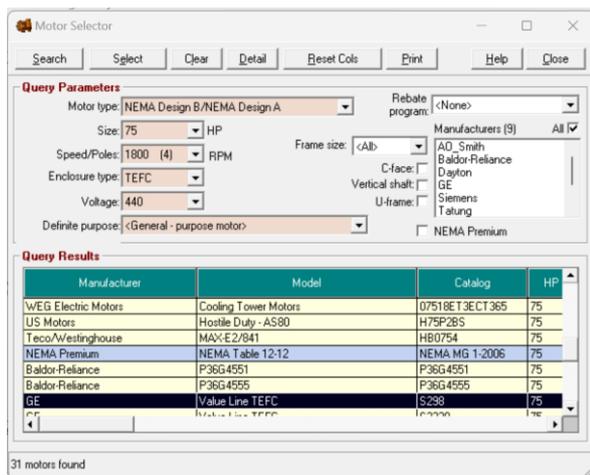


Figure 4: Choosing High-Efficiency Motors

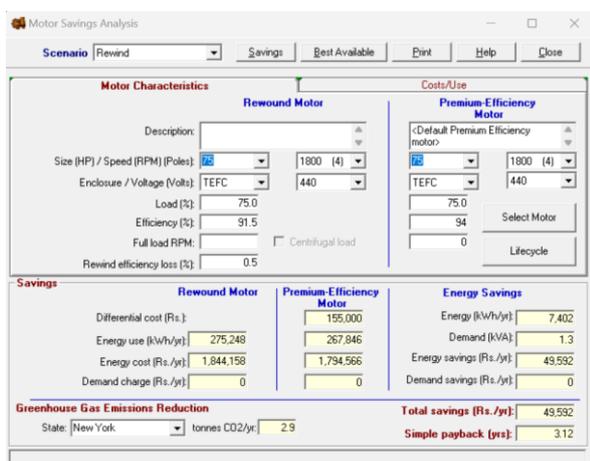


Figure 5: Motor Efficiency and Energy Savings Analysis

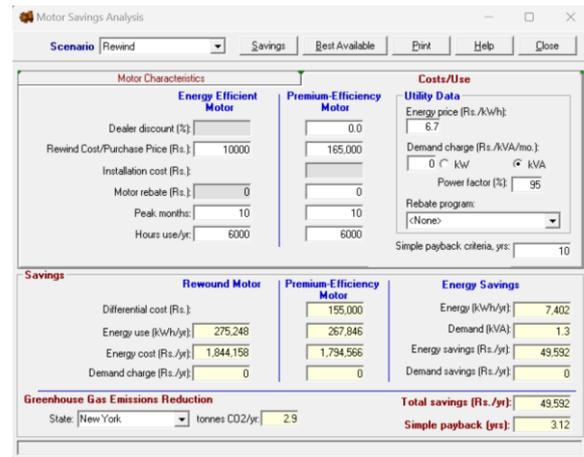


Figure 6: Analysis of Utility Consumption and Costs

Figures 4 to 6 show sample outputs from the software. The “Energy Saving” column represents the annual kilowatt-hour savings, while the “Payback Period” column indicates the number of years required to recover the investment in energy-efficient motors.

To purchase and install an energy-efficient motor for the Ring Frame, the company would need an investment of approximately Rs. 165,000. However, this cost would be recovered within 3.3 years through annual energy savings of 7,402 kWh, translating to a monetary saving of Rs. 49,592 per year. Therefore, implementing this measure in the factory is recommended to improve the efficiency of electrical energy usage.

VIII. CONCLUSION AND FUTURE WORK

In the selected textile industry, energy is primarily consumed in the form of electricity, which powers machinery, cooling and temperature control systems, lighting, and other essential operations.

Figure 3 illustrates the distribution of energy consumption across different sections of the spinning department, including blowing, carding, drawing, and ring frame operations. Among these, the ring frame and open-end spinning consume the most energy. In the overall textile process, spinning accounts for the largest share of electricity usage (44.7%), followed by weaving—including weaving preparation and weaving itself—at 29.7%. Based on the analysis of the plant’s energy intensity in Section 7 and comparisons with benchmark factories, there remain numerous opportunities for energy savings within textile plants.

Using the international software MotorMaster+, it has been observed that significant energy savings can be achieved by replacing standard motors with high-efficiency motors, often with short payback periods. Additionally, energy savings in the air compressor systems were realized by improving the installation and operation of equipment in the

humidification plant. Automation also plays a key role in enhancing energy efficiency.

ACKNOWLEDGMENT

The author sincerely acknowledges the support and guidance of all those who contributed to the successful completion of this research. Special thanks are extended to industry experts, textile plant management, and staff in the Bhilwara region for their cooperation during energy audits and for sharing valuable operational data. The author also expresses gratitude to colleagues and mentors for their insights on energy efficiency and conservation practices, and to Recon Energy Consultancy for providing a professional platform to pursue applied research in this field. Finally, heartfelt appreciation goes to family and well-wishers for their constant encouragement and motivation throughout the study.

REFERENCES

- [1] Electronic Concepts, Inc. "Power Factor Correction and Harmonic Control for dc Drive Loads", December 2004
- [2] US Department of Energy, Energy Efficiency and Renewable Energy – www.energy.gov
- [3] Bureau of Energy Efficiency, Govt. of India – www.beeindia.gov.in
- [4] Energy Efficiency Guide for Industry in Asia –“www.energyefficiencyasia.org”
- [5] Ernest Orlando Lawrence Berkeley National Laboratory, "Energy Efficiency Improvement and Cost Saving Opportunities in the Glass Industry, 2010"
- [6] Energy Audit Report of Textile Industries by RECON Energy Consultancy, Udaipur
- [7] The South India Textile Research Association (SITRA) The Textile Engineering & Instrumentation Division (<https://sitra.org.in/>)

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Kirtesh Bagarecha (b. 1987) is an Accredited Energy Auditor and energy management professional with over 15 years of experience in energy efficiency, conservation, and sustainability. He is currently CEO of Recon Energy Consultancy, Udaipur, where he leads energy audits, GHG accounting, and implementation of conservation measures across textile, cement, and chemical industries. Previously, he served as Senior Energy Consultant with Rajasthan Renewable Energy Corporation Ltd., Manager at Enfragy Solution India Pvt. Ltd., and Energy Manager at Reliance Chemotex Industries Ltd. His expertise spans benchmarking, feasibility studies, ISO 50001 audits, PAT scheme consultancy, and renewable energy projects. He

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