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(Research Article)

Energy audit of a textile company: A case study of finishing textile

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Abstract

In the contemporary textile industry, energy efficiency is not just an environmental imperative but also a financial necessity. This study presents a comprehensive energy audit conducted at a leading textile company to identify inefficiencies and propose strategic improvements. Through systematic data collection, regression analysis, and equipment performance evaluation, the audit revealed significant opportunities for energy conservation. Key findings include the potential for substantial energy savings through power factor correction, motor efficiency optimization, and lighting system upgrades. Implementing thermal insulation and steam condensate recovery further underscored the latent energy-saving prospects. Moreover, addressing compressed air leaks emerged as a critical area for reducing energy wastage. The study's recommendations, grounded in rigorous quantitative analysis, promise to enhance the company's energy profile and contribute to sustainable industrial practices. The anticipated outcomes of this audit are poised to set a precedent for energy management in the textile sector, with implications for cost savings and environmental stewardship.

Keywords: Energy Audit; Textile Industry; Energy Efficiency; Power Factor Correction; Motor Efficiency; Lighting System Upgrade; Thermal Insulation; Steam Condensate Recovery; Compressed Air Leaks; Sustainable Industrial Practices

1. Introduction

The textile industry, a significant contributor to the global economy, is also one of the most energy-intensive sectors. With rising energy costs and growing environmental concerns, the industry urgently needs to adopt sustainable practices. This paper presents a meticulous energy audit of a finishing textile company to identify energy inefficiencies and propose actionable solutions to enhance energy conservation. Drawing from the extensive data collected, including regression analysis, equipment performance, and energy consumption patterns, the audit scrutinizes every facet of the company's energy use. From the power factor variations depicted in Figure 3 to the motor loading efficiency assessments in Figures 4 and 5, the study delves into the granular details of the company's energy profile. It highlights the significant energy losses due to suboptimal power factors, inefficient lighting, motor motor rewindings, and the potential for recovery through steam condensate and reduction of compressed air leaks. The audit's findings underscore the importance of implementing energy-saving measures such as power factor correction, motor load optimization, and lighting system upgrades. Additionally, the study emphasizes the latent potential in harnessing thermal insulation and steam condensate recovery, replacement of inefficient boiler alongside mitigating compressed air leaks, to foster a more sustainable operational framework. This paper aims to provide a blueprint for energy optimization in the textile industry by integrating the insights from the audit's comprehensive analysis. The recommendations are expected to lead to significant cost savings and contribute to the industry's transition towards a more sustainable and environmentally responsible future.

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2. Material and methods

The textile company's energy audit was conducted using a systematic approach that combined qualitative and quantitative methods to assess energy consumption and identify inefficiencies within the facility. The methodology was designed to be comprehensive, covering all aspects of the company's operations, from power factor measurements to motor efficiency and lighting systems.

2.1. Data Collection: Data was collected through a series of steps

2.1.1. Review of Historical Energy Data

Analysis of past energy bills, equipment logs, and maintenance records to establish a baseline for energy usage.

2.1.2. Field Surveys

On-site inspections were conducted to observe operational practices and gather real-time data on energy consumption using specialized equipment such as infrared cameras, power loggers, and air leak detectors.

2.1.3. Interviews with Facility Personnel

Discussions with the staff to understand operational schedules, Energy conservation practices, and any known issues with the systems in place.

2.2. Analytical Tools and Techniques: Several analytical tools and techniques were employed to interpret the data:

2.2.1. Regression Analysis

Utilized to establish the relationship between energy consumption and production output, as detailed in Tables 1.

2.2.2. Energy Performance Modeling

Developed models to predict energy consumption based on production levels using the regression analysis results.

Table 1 Measured data Vs Predicted data

Measured Data				**Predicted Energy**			
Month	**Production**	**Specific Energy**	**Total Energy**	**Predicted Energy**	**Specific Energy**	**Difference Energy**	**CUSUM Energy**
	Kg	**Kw/Kg**	**Kw**	**Kw**	**Kw/Kg**	**Kw**	**Kw**
Jan-23	468660	22.1	10351771	9712398	20.7	639372	639372
Feb-23	445129	20.9	9320953	9274952	20.8	46002	685374
Mar-23	316080	23.1	7287551	6875927	21.8	411623	1096997
Apr-23	409957	21.9	8986758	8621092	21.0	365666	1462663
May-23	245290	20.2	4954219	5559943	22.7	-605724	856940
Jun-23	377023	24.5	9231274	8008862	21.2	1222411	2079351
Jul-23	474168	21.6	10263188	9814774	20.7	448414	2527765
Aug-23	424916	22.0	9336504	8899191	20.9	437312	2965077
Sep-23	509257	21.1	10741106	10467096	20.6	274010	3239087
Oct-23	540132	21.9	11835536	11041045	20.4	794491	4033578
Nov-23	520860	19.7	10271980	10682796	20.5	-410816	3622762
Dec-23	561090	19.4	10872342	11430672	20.4	-558330	3064431
Average EnPI		21.5		Average EnPI		21.0	

Compare measured and predicted monthly production, specific energy, total energy, and variances.

2.2.3. Power Factor Analysis

As depicted in Figure 1, we measured and analyzed power factor variations across different distribution boards to identify areas for improvement.

2.2.4. Motor Efficiency Assessment

Evaluated motor performance, including the impact of rewinding on efficiency, as shown in Figures 2

2.2.5. Lighting System Evaluation

The current lighting systems were assessed, and potential upgrades to more energy-efficient technologies were identified, supported by the data in Table 4.

2.3. Energy Audit Tools: The following tools were integral to the audit process:

2.3.1. Infrared Cameras

Used for thermal imaging to detect heat losses in processes and insulation.

2.3.2. Power Loggers

Deployed to record power consumption over time for various equipment.

2.3.3. Air Leak Detectors

Utilized to identify leaks in the compressed air system, which is a common source of energy waste.

2.3.4. Lux Meters

Measured illumination levels to evaluate the effectiveness of the lighting system.

2.4. Energy Conservation Measures (ECMs): Based on the data analysis, a set of ECMs was proposed

2.4.1. Power Factor Correction

During the Audit, it was observed that distributed panel 3 has a low power factor that is 0.779. Installation of capacitors can improve the power factor and reduce energy losses, as indicated by the discrepancies found in Table 2.

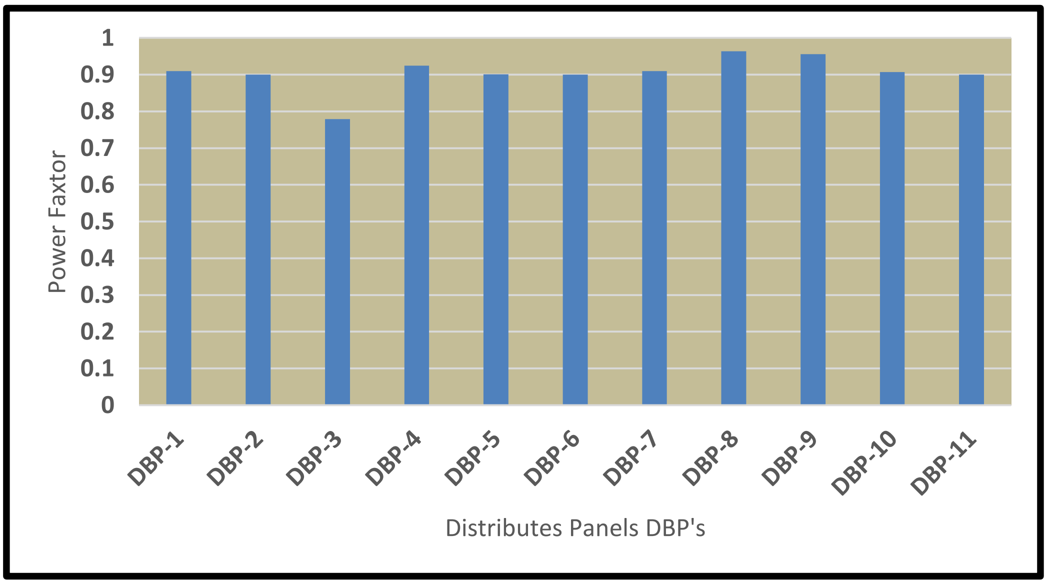

Figure 1 Power factor Variation at Distributed Panels(DB)

Table 2 Estimated Energy Savings through Power Factor Correction

Description	Measured				Calculation at PF=0.90		
	V	A	PF	KW	A	Saving Ampere	Kvar Required
DBP-3	399	264.6	0.779	142	228	36	46
Total					36 Amperes		
Yearly energy saving					56.00 kwh		
Note: 2,500 hrs/year,							

Compares Measured and Calculated Data at 0.90 Power Factor, Showing Energy Savings

2.4.2. Electrical Motor Analysis

It is observed that motor that is used at water supply department was rewinded, causing the high power consumption. Replacement of the rewind motor to enhance efficiency, as suggested by the findings in Table 3.

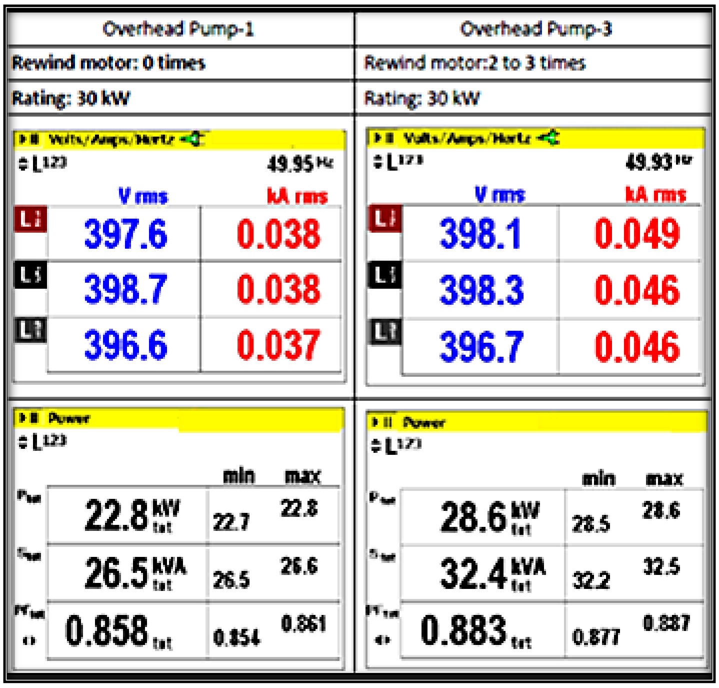

Figure 2 Electrical Consumption Comparison of Rewind & Unwind Motor

Table 3 Energy Savings by Using Unwind Motor

Description	Rewind Motor	New Motor
Horsepower (hp)	40	40
Running Power (kw)	28.6	22.8
Hours of operation per year (H)	2,800	2,800
Estimated Energy (kwh)	80,080	63,840
Saving per year	16,240 kwh	
Note : 8 hrs. per day, 350 days in a year		

2.4.3. Upgrading to Energy-Efficient Lighting

It was observed that it was estimated that Lighting Load is 4 to 5% of total industry load. The transition from traditional lighting to LED technology to reduce energy consumption and improve light quality is supported by the data in Table 4.

Table 4 Saving Potential in Lighting System by Using LED

Proposed Lighting	Exiting Lighting	Qty	Power Saving kW	Operation hrs.	Energy Saving (kWh)
FTL 28 W	FTL 40W	212	2.544	5,000	12,720
Led 65 W	CFL 65W	1.92	1.92		9,600

2.4.4. Thermal Insulation

During thermal insulation assessment of steam system, few Uninsulated points were diagnosed through thermal image camera. Application of insulation materials to steam systems can minimize heat loss, with potential savings outlined in Table 5.

Table 5 Estimating Saving from Thermal Insulation

S.No.	Location	Description	Annual Energy-Saving Potential GJ
1	WHRB#1 Entrance of hot flue gas	Heat loss area from the patch	25.96
2	Boiler Room	Heat loss area from Boiler front plate	72.09
3	Gas Boiler	Un-insulated feed Water line at boiler	46.73
4	WHRB Header	Flange	5.69
Total			150.47

2.4.5. Steam Condensate Recovery

During an energy audit, there were two major points where condensate was being wasted in to drain thus showing the potential to increase condensate recovery by 5%. Recovered condensate can be used as makeup water in the boiler which will reduce energy costs, as detailed in Table 6.

Table 6 Estimating Saving by improving 5% Condensate Recovery

Description	Value
Condensate Temperature	90 c
Makeup Water Temperature (average)	30 c
Calorific Value	38500 KJ/m3
AT	60 c
5% Condensate Recovery Weight	486 kg hr
Specific Heat of water	4.2 kj/year
No. of hrs per year	8,400
Energy Save per year	1,466 GJ/year

2.4.6. Replacement of inefficient Boiler

This section analyzes boiler efficiency of current gas fired boilde and recommends replacing the gas boiler with an efficient one, as shown in Tables 7.

Table 7 Energy Consumption Comparison between Existing and Proposed Efficient Boiler

Description	Value	Unit
Annually gas consumption Gas Boiler	6,001,737	Nm3
Gas Consumption per ton (current)	81	Nm3/Ton
Gas Consumption per ton (Proposed)	63	Nm3/Ton
Gas Saving per ton steam	18	Nm3/Ton
Annually Estimated gas saving	1,301,986.69	Nm3
Annually Estimated Energy Saving	48,173	GJ

2.4.7. Steam Leakage Management

Following are the steam leakages that were found due to audit. Determining and managing these steam leakages to prevent energy loss, as calculated in Table 8.

Table 8 Estimating Energy Loss due to Steam Leakage

Location	Description	Energy Loss GJ/year	Fuel Savings Nm3/year
Mini Steamer	leakage at steam supply valve	100	2,606
	Steam Leakage at machine	100	2,606
Pad Steam	Steam leakage below machines	75	1,954
WHRB Header	Steam valve leak	25	651
CRU	CRU PRV Leak Minor	25	651
MainSteam Header	Bleaching valve leak	25	651
Wider Steam Header	Steam valve leak	25	651
Wider Machine	Dry can safety valve leak minor	25	651
Total		400	10,421

2.5. Validation and Reporting: The effectiveness of the proposed ECMs was validated through

2.5.1. Simulation Models

Predictive models to estimate the energy savings from each ECM.

2.5.2. Energy Conservation Analysis

Financial analysis to determine the payback period and return on investment for each recommendation.

The energy audit results were compiled into a comprehensive report detailing the findings, recommendations, and expected outcomes. This report serves as the foundation for strategically implementing energy conservation measures within the textile company. The study emphasizes the importance of regular energy audits as a key component of sustainable industrial practices.

3. Conclusion

The comprehensive energy audit conducted at the textile company has illuminated a path toward significant energy conservation and operational efficiency. The audit's meticulous approach, encompassing a thorough review of historical data, on-site evaluations, and in-depth interviews, has culminated in a robust dataset, as evidenced by Tables 1-8 and Figures 1-2. These resources have provided a granular view of the company's energy profile, revealing critical areas for intervention.

The regression analysis and energy performance modeling underscored the strong correlation between production output and energy consumption, highlighting opportunities for optimization. The power factor analysis, motor efficiency assessments, and lighting system evaluations have identified actionable measures that can lead to substantial energy savings and cost reductions.

The proposed energy conservation measures, including power factor correction, rewind motor replacement, lighting upgrades, thermal insulation, and steam condensate recovery, are not merely recommendations but imperatives for the company's sustainable growth. The validation of these measures through simulation models and cost-benefit analysis has reinforced their viability and potential for a significant return on investment.

In conclusion, this energy audit is a testament to the transformative power of data-driven analysis in the textile industry. The company is poised to achieve a greener footprint, enhanced operational efficiency, and a competitive edge in the market by embracing the recommended energy conservation measures. The findings of this audit extend beyond the confines of a single company, offering a blueprint for energy optimization that can be adopted by the broader textile industry, aligning economic objectives with environmental stewardship.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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