A Study on The Efficiency and Sustainability in Solar Panel Manufacturing at Vikram Solar

S.ASWIN

43410294

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

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ABSTRACT

This study investigates the integration of efficiency and sustainability in solar panel manufacturing at Vikram Solar, a leading Indian solar energy firm. By combining operational observations with employee feedback (n=103), the research explores how automation, waste management, and energy optimization affect overall performance. Statistical tools including percentage analysis, chi-square, and ANOVA were employed to interpret data. Findings indicate strong sustainability initiatives, moderate automation adoption, and critical challenges such as equipment downtime and cost constraints. The study emphasizes lean manufacturing, predictive maintenance, and workforce training as pivotal strategies for enhancing both sustainability and efficiency.

Keywords: Solar Panel Manufacturing, Sustainability, Efficiency, Automation, Lean Manufacturing, Renewable Energy, Vikram Solar.

INTRODUCTION

The transition to renewable energy is accelerating globally, with solar power leading the charge. Efficient and sustainable manufacturing is essential to ensure that the solar industry maintains environmental integrity throughout its value chain. Vikram Solar, a major Indian solar panel producer, demonstrates notable efforts toward sustainable production. This research focuses on understanding the balance between operational efficiency and environmental responsibility in their manufacturing processes.

OBJECTIVES

Primary Objective:

To evaluate the efficiency and sustainability practices in solar panel manufacturing at Vikram Solar.

Secondary Objectives:

- To assess automation's role in improving efficiency.
- To understand waste and energy management strategies.
- To identify key sustainability initiatives and certifications.
- To recommend improvements based on employee feedback and industry benchmarks.

SCOPE OF THE STUDY

The research encompasses:

- Energy and material usage
- Degree of automation
- Recycling and waste management
- Compliance with environmental standards
- Sustainability integration in operations
- Comparison with global best practices

RESEARCH METHODOLOGY

- Design: Descriptive and analytical
- Sample Size: 103 employees at Vikram Solar
- Data Sources:
- Primary: Structured questionnaire
- Secondary: Industry reports, internal publications, ISO documents
- Analysis Tools: Percentage analysis, pie charts, chi-square test, ANOVA

REVIEW OF LITERATURE

The literature review highlights advancements in monocrystalline and bifacial technologies, resource optimization, waste recycling techniques, and lifecycle analysis frameworks. Vikram Solar's operations are aligned with global sustainability standards (e.g., ISO 14001), utilizing automation, green materials, and solar-powered facilities to reduce carbon footprints.

LIMITATIONS

- Initial investment barriers for sustainable tech
- Limited infrastructure for recycling in India
- Variability in supply chain sustainability
- Lack of real-time data transparency in external benchmarking
- Employee knowledge gaps in advanced sustainable practices

DATA ANALYSIS

Percentage Analysis Highlights

- Automation Impact: 75% reported positive impact
- Primary Efficiency Challenges: Equipment downtime (35%)
- Sustainability Practice Adoption: Energy-efficient production (60%), recyclable material usage (70%)
- Environmental Compliance: 85% perceive strong regulatory adherence
- Waste Recycling: 41–80% of production waste is recycled

Chi-Square Test

- Hypothesis: No significant relationship between waste minimization strategy and lean manufacturing impact
- Result: p = 0.308 → Not significant

ANOVA Test

- Hypothesis: Efficiency-sustainability scores vary with automation level
- Result: p = 0.507 → No significant variation

FINDINGS

- Strengths:
- High environmental compliance
- Effective waste management
- Employee engagement in sustainability
- Weaknesses:
- Equipment reliability issues
- Moderate automation (41–80%)
- Cost-related trade-offs between efficiency and sustainability
- Opportunities:
- Lean manufacturing adoption
- Technological investments
- Enhanced supply chain localization

SUGGESTION

- Invest in predictive maintenance and modern machinery
- Increase automation levels toward 80%+
- Implement advanced recycling and material reuse techniques
- Promote lean manufacturing and process optimization
- Enhance employee sustainability training programs
- Expand certifications and transparency (e.g., Carbon Neutral, LEED)

CONCLUSION

Vikram Solar stands as a strong example of integrating sustainability with industrial operations in the renewable sector. Though automation and lean practices have room for growth, the company's efforts in waste management, regulatory compliance, and employee participation are commendable. Addressing operational inefficiencies and scaling sustainable practices can further enhance its leadership in the clean energy sector.

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