Barriers and Cost-Benefit Analysis of Renewable Energy Adoption in Indian MSMEs

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ABSTRACT

Recently, the sustainability agenda has redefined industry particularly in new locations such as India where economic transformation and environmental protection often collide. Micro, Small and medium enterprises (MSMEs) are simply the support of the Indian economy, they create employment, enhance manufacturing of industries and even national exports. Although they are so critical, majority of these firms use fossil fuel power that is still old and that is why they are bound to changes in prices, supply hiccups and stricter regulations meant to reduce emissions.

Renewable technology, such as rooftop solar panels, biomass gasifiers, small wind turbines, and smart devices that conserve energy, will provide a game-changer to MSMEs, as they are able to reduce their expenses in the long-term and remain resilient. This report scratches beneath the surface of the challenges and the trade-off cost-benefits of shifting to green power in the Indian MSME sector. I relied on a combination of qualitative analysis and second source data, recent industry reports (2024-2026), and case study. The analysis examines cost, environmental and operational elements of the transition and uses sustainability and cost benefit models as a balance between the immediate costs and long term benefits such as secure energy supply and enhanced reputation in world supply chains.

The results reveal that the economic and ecological benefits are large-scale reduced running expenses and national climate achievement, but their extensive implementation is still restrained by large barriers. These are high start-up capital, difficult access to cheap credit, doubtfulness of the technology, and overall inability to know the niche technologically. Although early use has been brought by government incentives and policies, the report emphasizes the fact that we must still have more reforms, more regulations and effective communication efforts to accelerate the process of green industrialization in India.

INTRODUCTION

The modern energy landscape in the world is experiencing a significant shift with all the countries trying to balance the needs of economic development and at the same time address the pressing needs of climate change mitigation. The push towards renewable energy in India is also not an environmental goal but a fundamental strategy requirement towards taking the long-term energy security and industrial competitiveness. The Indian industrial sector was and to date, remains a major consumer of fossil fuels, specifically coal, in the country, forming a cornerstone of the Indian energy mix. Nevertheless, the increased prices of the conventional power, in addition to the unpredictability of the worldwide fuel market, have compelled the policymakers and business owners alike to consider cleaner options.

1. Indian History of Renewable Energy

The pace at which India is moving to a heavy grid of renewable energy has been remarkably high within the last twenty years. What started as a progressive collection of decentralized programs in the late 20 th century has been developed into a holistic national agenda to reach 500 gigawatts of non-fossil fuel capacity

by 2030. This changed with the government creating the National Solar Mission in 2010 which gave the institutional component and financial resources required to propel solar capacity to gigawatts, a dominance in the renewable energy sector. By 2025, the total renewable energy capacity in India had implemented a total of 253.96 GW, which is made up of 132.85 GW of solar energy, which was 41 percent higher than the last year. The strong regulatory framework such as the Renewable Purchase Obligations (RPOs) on board the utilities and the introduction of competitive bidding on large-scale projects have facilitated this historical growth. In the recent past, attention has moved to decentralized renewable energy (DRE) and allowing smaller players in the economy to take part in the energy transition. The flagship programs such as the PM Surya Ghar: Muft Bijli Yojana which was introduced in February 2024 are meant to solarize one crore houses, which is an extension of the government effort to democratize clean energy access. In the case of MSMEs, this record of policy stability can provide them a stable environment within which they can contemplate making long-term investment in green technology because the prices of solar equipment are kept falling through domestic manufacturing subsidies such as the Production Linked Incentive (PLI) scheme.

2. The MSMEs in Indian Economy

The role of MSMEs in Indian economic fabric can hardly be overestimated. The industry has a representation of more than 63 million businesses and a contribution of about 30 percent on the national GDP and almost 45 percent of total manufacturing output. Additionally, almost 48 percent of India export is done through MSMEs and therefore they are important players in the global value chain. It is also the second-largest employer in the country after agriculture as the sector offers livelihood to over 110 million people especially in the rural and semi-urban regions.

In 2020, the government introduced a revised classification for MSMEs to encourage growth and technological graduation. This classification, based on a composite criteria of investment in plant and machinery and annual turnover, is detailed in the table below:

Enterprise Category	Investment Limit (INR)	Annual Turnover (INR)
Micro	Up to 1 Crore	Up to 5 Crore
Small	Up to 10 Crore	Up to 50 Crore
Medium	Up to 50 Crore	Up to 250 Crore

Source:

Most MSMEs have low profitability levels despite their economic bulk and are prone to slight changes in the cost of operation. Energy costs tend to be 15 to 30 percent of the total operation costs of the manufacturing plants in the textile, foundry, and food processing industries. The dependence on grid power which is frequently subject to quality problems and increasing tariffs and the high-frequency usage of costly diesel generators in the event of a failure results in a long-standing financial strain. As a result, the utilization of renewable energy is nowadays regarded as a method of financial optimalization and as a possibility to cushion business against the vagaries of the traditional energy market.

3. Significance of Sustainability and Transition of green energy

The concept of sustainability has gone beyond its beginnings as a corporate social responsibility (CSR) concept to become a pillar of the business strategy in the modern world. Within the globalized industrial environment, sustainability is characterized by Triple Bottom Line (TBL), which holds the view that an organization should quantify its success in the economic viability, environmental impact as well as social contributions. To the Indian MSMEs, the most practical way of matching these principles is to shift to green energy. Enterprises may decrease their impact on the environment considerably by minimizing the emission of greenhouse gases and reducing the use of fossil fuels.

Besides, the shift to green energy is becoming a market-driven process more. World consumers especially in European markets and North America are currently demanding assurable ESG (Environmental, Social, and Governance) conformity among their suppliers. Introducing the Carbon Border Adjustment Mechanism (CBAM) by EU is one of the most common illustrations of how environmental regulations are turning greenhouse industries into trade obstacles. Incorporating renewable energy by MSMEs today does not only help to reduce electricity expenses, but it also safeguards their future in terms of accessing international markets. In this case, digitalization acts as a supplement, since AI-based energy management systems and smart meters can enable companies to report on their carbon cuts in a transparent manner, which helps the business gain more credibility with international collaborators.

4. Relevance of Renewable Energy Adoption in the Industry

India is a country where renewable energy has an industrial value due to the huge disparity between the grid tariff and the levelized cost of solar power. Grid electricity rates in most industrial belts are between [?]7 and [?]11/kWh and the cost of generating solar energy in locations has come down to between [?]2.5 and [?]4/kWh. This is an attractive economic adoption incentive. These savings would benefit most sectors that have high thermal and electrical needs (i.e. textile processing, foundries, and ceramics).

In addition to direct cost savings, renewable energy also offers a buffer in the face of grid uncertainty; the frequent power cuts and voltage spikes which may destroy delicate industrial equipment. Financial survival in clusters such as Tiruppur where almost 40 percent of the cost of running common effluent treatment plants (CETPs) is electricity implies that the transition to renewables is a precondition of survival. The year 2025 is now a marker as solar was no longer a plan ahead but rather a business decision of the current moment because the owners of the factories started to understand that reliable energy prices are an asset in the long-term outlook and allow cushioning the margins against inflation.

5. Purpose and Objectives of the Study

The primary objective of this research project is to learn more about the present situation of the adoption of renewable energy by the Indian MSMEs and also to find out the major elements that can positively or negatively affect this adoption. Based on the heterogeneity of the industry, the paper is expected to make a nuanced contribution towards the distinctiveness of the prevalence of various obstacles that consist of financial, technological and regulatory in the various industrial clusters.

The details objectives of the research are as follows:

The purpose is to determine the rate and existing trend of the use of renewable technologies such as solar, biomass and energy saving systems among MSMEs.

* To identify the key structural and operational challenges capable of halting increased use of these technologies.

To perform a cost benefit analysis of the cost as well as advantages of traditional sources of energy compared to renewable sources of energy in an attempt to determine the financial feasibility.

* To explore the question of whether the government policies, such as MSE-GIFT and ZED Certification schemes have enabled the green energy transition.

Sections such as brand equity and market access are part of the long-term and environmental strategic benefit of adoption and the need to investigate this.

6. Structure of the Paper

The primary objective of this research project is to investigate the status of adoption of renewable energy among the Indian MSMEs besides determine the major factors that could contribute to the adoption or retard the adoption. Given that the sector is diverse, it is expected that subtle insight should be given by the paper to the variations in the presence of various barriers, which are financial, technological and regulatory in the various industrial clusters.

These are the objectives of the research:

To determine the adoption and the existing trend of renewable technologies such as solar, biomass and energy efficient systems among the MSMEs.

* To identify the key structural and operational barriers that will prevent a higher use of these technologies.

In this case, to conduct a cost benefit analysis of the cost and benefits of conventional energy sources and renewable energy sources in order to determine financial viability.

* To examine whether the government policies such as MSE-GIFT, and ZED Certification schemes have enabled the transition to green energy.

* To investigate the strategic benefit of adoption, both long term and the environmental, including, brand equity and market access.

REVIEW OF LITERATURE

The academic interest in the topic of renewable energy uptake by MSMEs has been experiencing massive steam due to the global community trending towards a net-zero future. To understand the reasons why small firms are likely to be lagging behind large corporations in adopting green technologies despite the evident economic advantage of using them, researchers have been using a variety of theoretical perspectives. This literature review will combine the most important theoretical premises and empirical evidence that will guide the present study.

2.1 Diffusion of Innovation theory

The most potent school of thought that is used to explain the adoption of new technologies is the Diffusion of Innovation (DOI) theory, which was created by Everett Rogers. Rogers (2003) hypothesized that adoption does not happen overnight but a process that is gradual and takes place over a period of time through certain channels of communication between members of a social system. Five perceived attributes of the innovation are used to determine the rate of adoption and they are relative advantage, compatibility, complexity, trialability, and observability. The potential of a large saving on electricity bills can be viewed as the relative advantage of MSMEs. Nevertheless, complexity, which is perceived as the difficulty in understanding and applying solar or biomass systems, is a frequent demoralizing factor. There is also the problem of compatibility since the current industrial infrastructure will need to be retrofitted with some serious work to add renewable sources. Empirical evidence has demonstrated that in clusters where successful adoptions can be observed, diffusion is faster due to peer effects that affect the neighboring firms. According to 2025 research findings, with the growing information propensity of MSMEs, their emphases in the evaluation of the cost are not on the initial cost only, but on the lifecycle performance of the technology, which is a maturation in the diffusion process.

2.3 Cost-Benefit Theory

The Cost-Benefit Theory is another imperative framework where organizations act rationally and only make the decision to invest in new technologies as long as the perceived advantages exceed the expenses incurred within a given period. When applied to renewable energy, this is a systematic assessment of capital expenditure (CAPEX), operating and maintenance expenses (OPEX) and levelized cost of energy (LCOE) and the grid tariff of conventional energy. The major tools of this analysis are financial indicators like Net Present Value (NPV), Internal Rate of Return (IRR), and the Payback Period. The NPV is determined as follows LaTeX: The net cash flow (savings) at time is given and the discount rate and the initial investment are known. Research papers by the International Renewable energy agency (IRENA) have established that the LCOE of solar PV is increasingly on the downward trend and has become the most cost-effective opportunity to MSMEs in sun-rich nations such as India. But to most small companies, even a profitable investment could not be realized at high "discount rates" because credit is expensive.

2.5 Corporate Environmental Responsibility and Sustainability Theory

Corporate Sustainability Theory also forms the foundations of the transition to green energy and is becoming more concerned with the Triple Bottom Line. The Brundtland Report (1987) provided the basis definition of sustainable development, which in the new interpretation defines businesses as custodians of natural capital. This has in the 2020s transformed into the ESG (Environmental, Social and Governance) model used by investors and other large companies to assess the risk and sustainability of their supply chain members in the long term.

Not only are M SMEs that have embraced renewable energy building reputational capital, they are also saving money. According to the sustainability theory, this intangible resource will improve brand trust and entry to high-end markets. Moreover, the concept of Zero Defect, Zero Effect (ZED) that is promoted by the Indian government coincides with this theory because it pushes MSMEs to reduce their footprint on the environment as one of the ways to achieve global competitiveness.

3. Existing Research on the adoption of renewable energy

Empirical studies around the world have come up with a uniform set of obstacles and drivers. Initial research by Painuly (2001) did not show any policy uncertainty and financial constraints as universal barriers. In the European market, the awareness and external financing availability were the main drivers of the small businesses (Sardianou 2008). The Indian context has received much research on the issues of MSME ecosystem peculiar to India. According to Bhattacharyya (2015) and others, even though the industrial cluster is an optimal setting to adopt solar because of the shared infrastructure and information, non-price frictions remain high, including the net meter slowdown on bureaucracy. In 2025, reports by NITI Aayog note that by decarbonizing the sector via rooftop solar and energy efficiency, by sustaining the sector has the ability to cut MSME emissions by up to 87 MtCO2e each year so long as the sector can draw in the necessary 2 lakh crore of private investment.

6. Research Gap

Although extensive literature is available on the large scale renewable energy initiative and corporate social responsibility in developed countries, there is a large gap in the organized study of MSME segment in the developing economies such as India. In the available literature, emphasis has been on either policy analysis or the environmental benefits and not many studies are offering a detailed cluster specific cost-benefit analysis based on small business owners. Moreover, the relationship between digitalization and green energy uptake in MSMEs is underresearched- a very significant omission in view of the fast technological changes of the mid 2020s. This paper will attempt to address these gaps by combining tangible financial

evidence, recent policy changes (2024-2026), and the qualitative aspects of the decision-making of MSME founders.

PROBLEM STATEMENT

The major issue in the Indian industrial scene is the loss of the close relationship between economic growth and carbon intensity. Although the MSMEs are the driving factor in the job creation and production of industries, they also pose a major contributor to the environmental degradation in their use of old fashioned energy consuming technologies and fossil fuel generated energy sources. In spite of the obvious financial benefits of renewable energy sources onsite solar generation being almost 60-70 percent cheaper than grid power, the adoption rates keep not exceeding the obstinate position. The under-adoption is based on a complex of issues. First of all, the first capital barrier is very high. A 100 kW solar system needs an initial cost 40 to 55 lakh which is beyond the liquidity of many micro and small businesses. Availability of cheap financing is also an issue; the banks usually consider MSMEs as risky borrowers and require huge collateral or high interest rates as a result of credit guarantees schemes by the government. Moreover, the lack of trust and the lack of information are widespread. The quality of low-quality solar installations that do not yield the promised results has discouraged many MSME owners, and instead of considering the lifetime performance of the installations, they have concentrated on upfront price as opposed to lifetime performance. This is enhanced by technical illiteracy on the recent technological solutions and awareness on specialized monetary incentives such 2% interest subvention as a part of the MSE-GIFT scheme. There is the complexity of regulatory hurdles. The approvals required to install the net metering procedure can take longer than the required average 30 day period to more than 120 days as a result of bureaucratic delays and lack of sufficient coordination between vendors and distribution companies (DISCOMs). There is an urgent necessity of a systemic analysis that would cover these structural, financial, and informational obstacles and a clear roadmap on the way MSMEs will pass through the process of going green.

RESEARCH OBJECTIVES

This paper aims to offer a detailed analysis of the renewable energy uptake situation in the Indian MSME industry. The research is guided by the following specific objectives:

- To assess the existing trends of adoption and marketization of rooftop solar, biomass and energy efficient technologies on MSMEs in representative industrial clusters.
- To define and classify the financial, technical, and regulatory obstacles which are major adoption impediments.
- To conduct an in-depth cost-benefit analysis of CAPEX and OPEX models of the implementation of solar and biomass energy.
- To determine whether the existing government policies (2024-2026), namely the MSE-GIFT, the ADEETIE, and ZED Certification schemes have been effective to promote the involvement of MSMEs.
- To explore the environmental and social effects of adoption, it is necessary to put the emphasis on the potential of carbon offset and the establishment of green jobs.
- To offer strategic advice to MSME managers and policymakers in order to hasten the green energy transition and make industries more competitive.

RESEARCH METHODOLOGY

This research will use a qualitative and analytical research design because it aims to explore the intricate dynamics of adoption of renewable energy in the MSME sector. Considering the complexity of the barriers, which includes high-level policy frames and firm-specific financial limitations, the study is based on the synthesis of multiple types of data so that the comprehensive perspective can be reached.

1. Research Design and Data Sources

The research is founded mainly on the secondary data that is neatly collected in the form of peer-reviewed academic journals, government publications, and industry reports of the 2024-2026 timeframe. The primary sources are the reports of the Ministry of New and Renewable Energy (MNRE), the Bureau of Energy Efficiency (BEE), NITI Aayog, and the international organizations, namely, the IEA and IRENA. In order to base the theoretical analysis on actual outcomes, the study uses sectoral case studies of MSMEs in high-energy-intensive clusters as textiles, food processing, and foundries.

2. Analytical Methods

The study uses a number of analytical methods to assess the adoption situation:

- **Cost-Benefit Analysis (CBA):** This is a technique to ascertain the financial feasibility of renewable investments, taking into account expenses and expenses incurred in upkeep and savings of electricity expended within a 25-year life cycle. The most important indicators such as Payback Period and Internal rate of Return (IRR) are estimated based on the current market data.
- **Thematic Analysis:** This strategy is used to determine that is common among the various studies and case reports in order to classify the barriers and success factors. It is possible to identify cross-cutting themes, including the theme of financing gaps and information asymmetry.
- **Comparison and Analysis:** The paper provides a comparison of two models of solar adoption in terms of fiscal implications with CAPEX (direct ownership) and RESCO (third-party ownership) models to decide which one is most appropriate in relation to the size of the MSME.

3. Scope and Limitations

The research is dedicated to the Indian MSME ecosystem, and the Indian manufacturing units in energy-intensive clusters are considered in particular. Although the study is comprehensive, it may fail to reflect all the current policy changes or local diversity of electricity tariffs as it is drawn on secondary data. Nevertheless, the study can be characterized by high validity and relevance of modern business managers and policymakers as numerous authoritative sources and the latest industry statistics are used.

ANALYSIS & DISCUSSION

The review of adoption of renewable energy in MSMEs demonstrates that it is a sector that is at a crossroads. The economic rationale to adopt is increasingly becoming a fact but the working reality is marked by high friction.

1. Overview of MSMEs and Energy Consumption Trends

Indian industry is mainly based on MSMEs, especially in the specialized clusters. By 2025, energy economics has necessitated a significant change in industrial belts - the auto clusters of Pune to textile belts of Tiruppur. The industries that consume a lot of energy tend to use a combination of grid power, diesel as a backup form of power, and coal or natural gas as thermal power.

Industrial Sector	Typical Energy Usage	Primary Energy Lever
Textile Processing	15–30% of OPEX	Solar PV, Wind, Waste Heat
Metal Foundries	High (Melting/Casting)	Energy Efficient Furnaces

Industrial Sector	Typical Energy Usage	Primary Energy Lever
Food Processing	Moderate (Refrigeration)	Solar PV, Biomass Boilers
Ceramics	Very High (Kilns)	Fuel Switching (Biomass/PNG)

Source:

In the energy-intensive sectors, 91% of the total emissions are caused by grid electricity and coal with 50% being caused by coal. By switching to cleaner sources such a PNG and biomass, emission may decrease up to 16 MtCO2e in case of a transition that is aggressive..

2. MSME-Friendly Renewable Technologies

The "MSME-friendly" label in 2026 is applied to technologies that are scalable, affordable, and easy to maintain.

- **Solar Rooftop Systems:** These are the most popular one because there is a lot of space on the rooftops on factory sheds. In 2025, high-efficiency bifacial modules of both TOPCon and Mono PERC have become the industrial standard providing an improved yield even in high-temperature areas such as Nagpur or Vidarbha.
- **Biomass Energy:** Biomass gasifiers are specifically applicable in fields such as agro-based industries where agricultural wastes such as rice husk or bagasse are converted into clean thermal energy and electricity.
- **Energy Efficiency Technologies:** Biomass gasifiers are specifically applicable in fields such as agro-based industries where agricultural wastes such as rice husk or bagasse are converted into clean thermal energy and electricity.

3. Financial Analysis: Conventional vs. Renewable Energy

Due to the enormous difference between grid tariffs and the cost of solar generation, the financial feasibility of solar adoption is realized. In Maharashtra and Gujarat the industrial grid tariffs are around [?]11/kWh and the generation cost of the solar is [?] 2.5 to 4/kWh.

Parameter	Grid Electricity	Solar (CAPEX)	Solar (RESCO/PPA)
Cost per Unit	₹11.00 - ₹12.00	₹3.00 (LCOE)	₹5.00
Monthly Bill (20k units)	₹2,30,000	~₹60,000*	₹1,00,000
Payback Period	N/A	3–5 Years	Immediate Savings

Note: After payback, cost is mainly maintenance (~₹0.5-₹1/kWh). Source:

The CAPEX-based solar systems Payback Period of CAPEX-based systems in sun-rich states has been reduced to a lower figure of less than 4 years in case of government subsidies. The MSMEs are under a model known as RESCO (Renewable Energy Service Company), under which they will be able to solarize their premises without any initial investment and will pay fixed rates of approximately 5.00/kWh of power over 20-25 years, which will be a major strategic benefit compared to the uncertainty of variable rates in the grid.

4. Barriers to Adoption: Structural and Operational

There are contradictory obstacles to adoption:

- **The First Capital Barrier:** A 100 kW system continues to cost 100000-500000 lakh, and this is a significant working capital requirement of small companies.
- **Financing and Credit Gaps:** Although the trend of digital lending is growing, most MSMEs lack access to extra financing of 10-20% margin money or other collateral, which the banks expect. NBFIs offer faster loans although at a greater interest rate(10-14), giving a trade off between speed and cost.
- **Engineering Quality and Trust:** With cost-effectiveness, it became clear in 2025 with a wave of lessons learned where MSMEs that emphasized the cheapest solar panels had to shut down and maintain high maintenance. This has put the market skewed to the Quality-First manufactures that have 25 to 30 year performance warranties.
- **Regulatory Friction:** The uncertainty on the project ROIs due to the regulatory delays in the net metering approvals and fluctuations in state banking policies (e.g., attempts to restrict banked solar power to solar hours) cause uncertainty in the project ROIs.

5. Government Policies and Incentives (2024–2026)

Indian government has initiated some aggressive programs to reduce these barriers.

- **MSE-GIFT (Green Investment and Financing to Transform):** Provides 2% interest subvention on green technology loans, of up to 2000000.
- **ADEETIE (Assistance in Deploying Energy Efficient Technologies):** It is a 5% interest subversion under Micro/Small and 3% under Medium enterprises implemented by BEE and aims at 14 energy-intensive branches.
- **MSME Sustainable (ZED) Certification:** A redesigned initiative that provides certified subsidies (up to 80 percent of Micro) and financial support of up to 3 lakh INR on certification upgrades of the technology named Zero Effect.
- **Union Budget 2026-27:** Increased the MNRE budget to 32,914 crore, 22,000 crore of which over PM Surya Ghar and 5,000 crore of which over PM-KUSUM (agri-solar).

6. Case Studies: Tiruppur, Punjab, and Maharashtra

- **Tiruppur (Textiles)**: The cluster is currently producing 1,900 MW of wind and solar energy, which is fivefold of its operational requirement. This has enabled the exporters to have a 22% growth rate through adhering to the global ESG standards, which has been effective to counter the effect of the US and EU carbon tariffs.
- **Punjab (Rice Mills)**: 8.8 lakh metric tons of paddy straw is currently being used in biomass gasification plants to cut 85 percent of stubble burning and produce ₹500 crore of annual farmer earnings as well as supplying mills with inexpensive thermal energy.

- **Maharashtra (Food Processing):** A ground-mounted 3MW project located in Nashik will operate a poultry feed plant and generating payback after 3 years will help the company save 30 lakh in monthly energy bills.

7. Environmental Impact

Adoption of renewable energy by MSMEs forms the part of the Net Zero 2070 commitment made by India. An average 100 kW solar project neutralized about 120 to 150 tonnes of CO 2 annually. Cumulated on the sector level, rooftop solar and energy efficiency can provide as much as 87 MtCO2e in terms of emission reductions by 2030. Also, the transition will result in the generation of 17 lakh direct green jobs in manufacturing, installation and maintenance which will be a major social pay off.

CONCLUSION

The shift towards renewable energy in the Indian MSME industry has transformed to be a question of environmental preference to an issue of strategic imperative. The tedious examination that is undertaken in this paper proves that although the economic feasibility of green technologies, especially, rooftop solar and biomass is strong, the road to implementation is still full of organizational challenges. The results show that the lack of integrated support systems has become the greatest obstacle since technology is no longer the greatest challenge. Although the 2026 budgetary plans and schemes such as the MSE-GIFT and ADEETIE offer the much-needed financial breathing space, the "non-price frictions" such as regulatory lags in net metering and absence of standardized technical handholding remain in the way to the motivation of small business owners.

Managerial Implications

To the managers of MSMEs, the move involves a performance-over-price orientation. A more expensive initial investment such as in high quality TOPCon or Mono PERC modules and energy efficient motors can be worth it in terms of less downtime and longer life cycle that provide a significantly superior IRR. It is also suggested that managers use the ZED Gold Certification as a marketing weapon to establish alliances in the ever-greening world market.

Policy and Regulatory Implications

Policymakers must move beyond just providing subsidies to ensuring "execution certainty." This involves:

• Standardization of net metering and banking policies in all states in order to eliminate uncertainty of ROI

• Aggregation of demand in industrial clusters where smaller units can be involved in community solar or RESCO projects.

• Quickening the digitalization of the onboarding of the ZED and MSE-GIFT schemes so that even the tiniest micro-enterprise can have access to the benefits without imposing red tape.

To sum up, as renewable energy components are made more affordable with the help of domestic manufacturing (PLI) and the financial ecosystem becomes established with the help of special green loans, the MSME sector is ready to undergo the revolution of clean energy. Such alignment of the operational efficiency with the national climate goals can help Indian MSMEs not only to achieve reduced costs but also to become the world leaders in sustainable manufacturing.

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