Summary for Policymakers

Estimating Skilling Needs and Filling Skill-gaps for India's Industrial Energy Efficiency

April 2025

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I. Introduction

Commonly touted as the "first fuel", energy efficiency (EE) serves as a catalyst for clean energy transitions. Amongst the bouquet of technology levers, it is often treated as the first line of defense when it comes to emission reduction. The multitude of benefits emanating from EE spans across sectors and covers a plethora of aspects, such as generating energy savings, enhancing employment, raising productivity improvement, poverty alleviation, promoting energy security, and much more.

In line with the updated Nationally Determined Contribution (NDC) targets, India strives to achieve energy savings to the tune of 150 mtoe[1] by 2030, against the earlier target of 86.9 mtoe. As of 2024, the country's rate of energy intensity improvement is estimated to be 2.5 percent, compared to the global average of 1 percent (PIB, 2024). This would need to increase to 4 percent, in order to achieve the target of doubling EE improvements by 2030.[2]

For the purpose of actualizing the national goals, states are being encouraged to proactively contribute toward the same.[3] Using the proportional shares of the erstwhile target (BEE 2019), the sectoral breakdown indicates that the highest share has been allocated to the industrial sector (54.7 percent), followed by transport (18.2 percent) and residential (13.9 percent) sectors. As of 2023-24, the industrial sector accounts for more than half (~51 percent[4]) of the total final energy consumption (TFEC) in the country (MoSPI, 2025). This warrants the need to focus on strategies to improve industrial energy intensity via the implementation of energy-efficient practices and the adoption of suitable technologies. Parallelly, with State Energy Efficiency Action Plans (SEEAPs) being formulated at the sub-national levels, translation of the same into on-ground implementation is contingent upon the availability of a skilled workforce.

Against this backdrop, the objective of this study is to draw focus on EE-relevant employment in India's manufacturing sector, using an internationally comparable estimation method. It assesses existing skill levels, highlights the need for skill enhancement at the state level, and integrates findings into ICRIER's state-level '***Unnati***' CGE model to evaluate the benefits of addressing skill gaps through skilling, upskilling, and reskilling.

[1]Million tonnes of oil equivalent (mtoe)

[2]Available at: https://sansad.in/getFile/annex/267/AU2713_yEX07t.pdf?source=pqars. Accessed on 12 April, 2025.

[3]Available at: https://www.business-standard.com/article/economy-policy/centre-asks-states-to-expedite-energy-efficiency-activities-on-mission-mode-123022600380_1.html. Accessed on 12 April, 2025.

[4]Provisional figures as per Energy Balance of India 2023-24.

II. Policy Relevance & Research Question

While much of the existing literature and policy focus has been limited to estimating the financial needs of clean energy transitions and employment generation from increased renewable energy penetration, the potential of EE is often underestimated. There is an urgent need for the policy discourse to also highlight EE's contribution—not only to decarbonization but also to economic development through employment creation.

The research addresses two critical policy areas: employment generation and skill development. India's commitment towards skill development is reflected in the recently extended Skill India Mission (till 2026), backed by a restructured framework and an INR 8,800 crore outlay. The primary focus of the same is to provide industry-aligned structured skill development (PIB, 2025)[5] . The program aligns well with the study's emphasis on estimating EE-relevant employment at the granular level of tasks and occupations, and identifying existing skill gaps across select states.

These insights can guide state-level EE action plans and skill development strategies through the identification of industrial segments with untapped skilling potential. Targeted interventions in these areas can help build a robust pipeline of EE-skilled professionals—a foundational step toward leveraging India's demographic dividend for a cleaner, greener, and cost-effective development path.

Research Question

Building on the mentioned narrative that EE serves as a catalyst for clean energy transitions, the study explores the EE manufacturing employment potential in the country and attempts to answer the following research questions:

a. What is the prevalent EE-employment structure in the existing manufacturing landscape of the country? What are the dynamics of the EE structure in terms of diverse industries, occupations, skill levels as well as the skilling requirements of the sector?

b. What is the impact of various skilling initiatives on employment creation in the energy sector? What are the existing constraints to the upscaling of EE in the focus states?

c. What are the critical policy interventions that can effectively support workforce skill development to enhance EE outcomes in Indian industries?

The following sections provide a brief overview of the methodology adopted for the employment assessment, the results so obtained and the implications of the same for the larger macroeconomy.

[5]Available at:

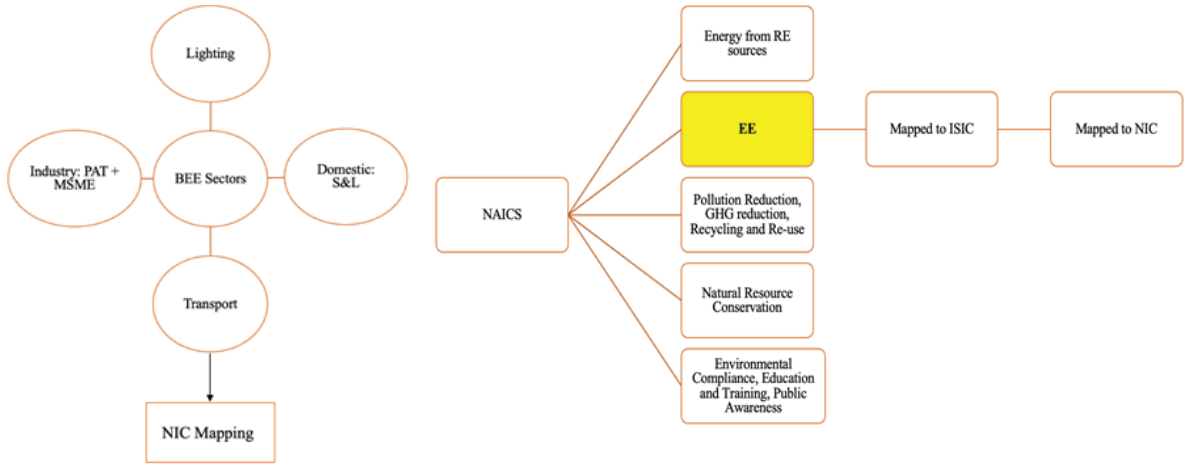
https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2100845#:~:text=The%20Union%20Cabinet%2C%20chaired%20by,%2D23%20to%202025%2D26. Accessed on 12 April, 2025.

III. Methodology

1. **Employment Assessment** – Dual-approach adopted

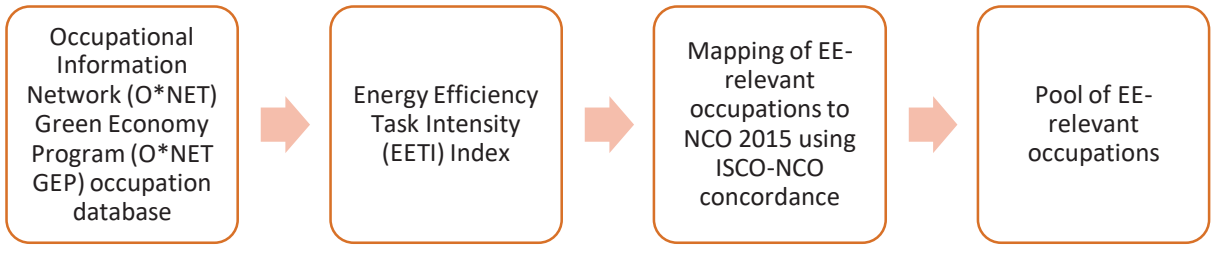
a) Output-based approach - Objective: Identification and creation of a pool of EE-relevant industries for India

Figure 1: Assessment of EE-relevant industries



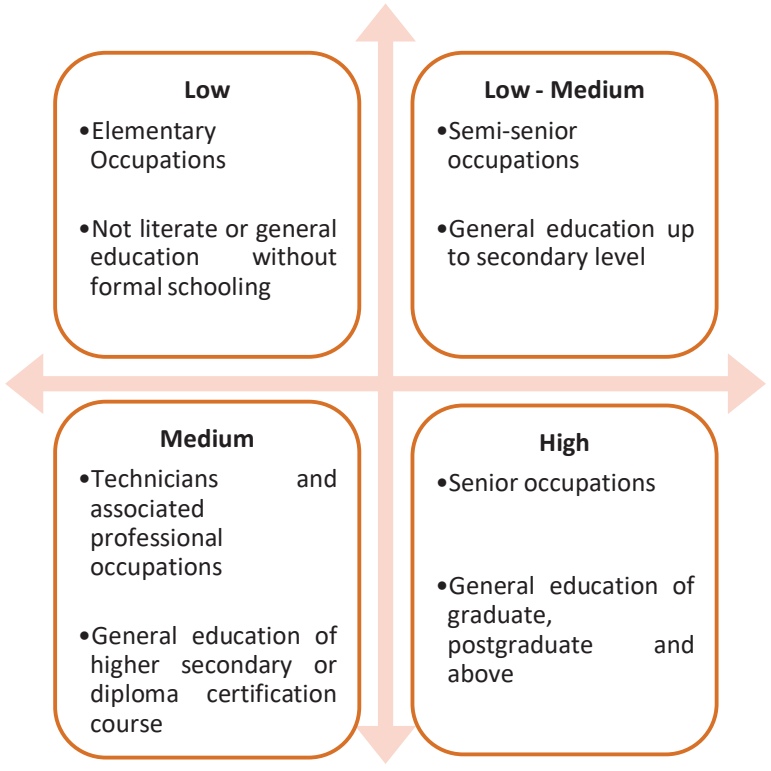
b) Task-based approach - Objective: Identification and creation of a pool of EE-relevant occupations for India

Figure 2: Assessment of EE-relevant occupations



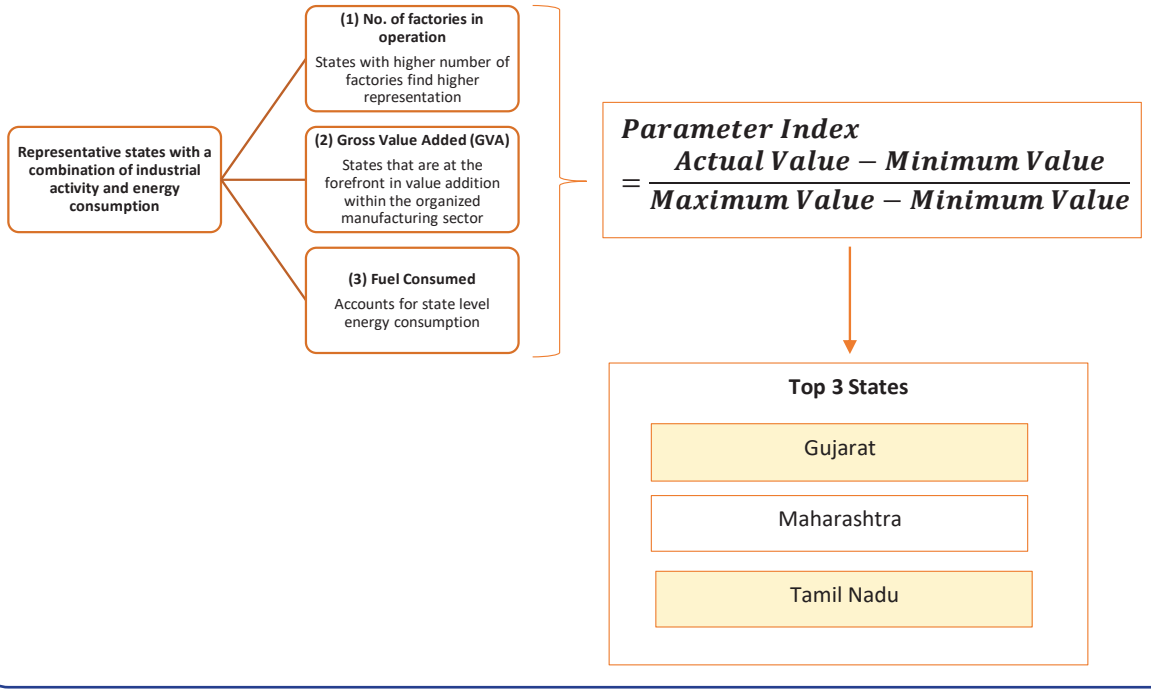
2. Skill Assessment

Figure 3: Skill definition



3. State Selection

Figure 4: State selection methodology

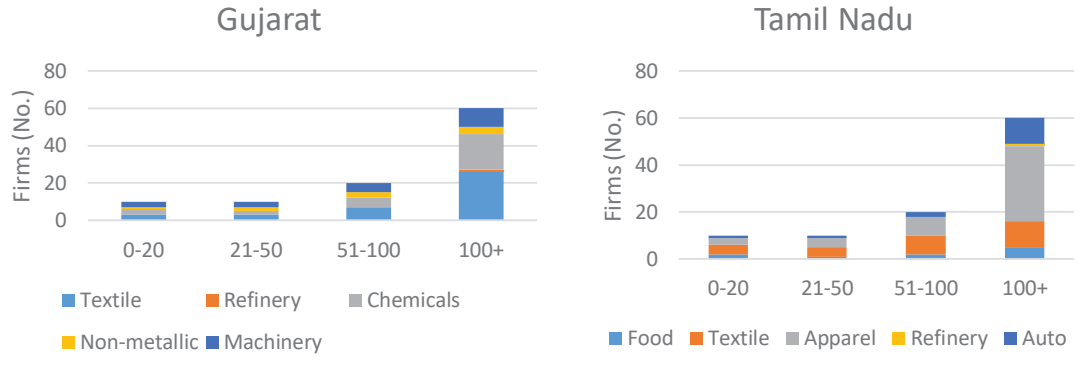


4. Survey Industry Selection

The survey methodology focused on identifying relevant industries and firms using the Annual Survey of Industries (ASI) Frame (2023–24) and ASI Microdata (2022–23). The approach involved two key steps: spatial shortlisting to identify major industrial clusters in Tamil Nadu and Gujarat, and industrial shortlisting using a weighted score based on the number of factories, Gross Value Added (GVA), and fuel consumption at the 2-digit NIC level. Firms were further categorized into four employment size groups (0–20, 21–50, 51–100, 100+) and proportionally distributed across industries to ensure balanced representation.

This structured approach ensured that the selected sample was representative of each state's industrial landscape. By concentrating on key clusters and energy-intensive sectors, the survey captured firm-level variations across sizes and sectors. The sample distribution by industry and size class is presented in Figure 5. The survey findings offer critical insights into EE practices, adoption trends, awareness levels, and the challenges firms face, setting the stage for the section that discusses the results in detail.

Figure 5: Sample Distribution



5. ICRIER *Unnati* model description

The ***Unnati*** model developed by ICRIER investigates the skilling needs for scaling EE by distinguishing between skilling, reskilling, and upskilling needs at the state level. The model is based on a Computable General Equilibrium Model (CGE) dynamic framework, which captures the relationship between agents and different sectors of the economy, allowing for analysis on how changes in one sector could affect the other sectors.

The primary agents in the model include households, producers, government, and the rest of the world, which play certain roles to bring various markets, such as production, factor and commodity markets, into equilibrium. The interaction between the agents and the markets results in macroeconomic equilibrium, where demand and supply gaps, government budget, and trade balance are met, ensuring an efficient economy.

The model is dynamic, projecting variables till 2030 employing Mathematical Programming System for General Equilibrium (MPSGE) framing using general algebraic modelling system (GAMS) software

for solving. The model implements market-clearing, zero-profits and income balance condition, and solves all equations using a Mixed Complementarity Problem (MCP) formulation. Additionally, the model is built along the lines of IFPRI standard CGE model, though it is implemented in MPSGE rather than in standard GAMS coding.

The current version incorporates several refinements from the previous version, with new elements enumerated below:

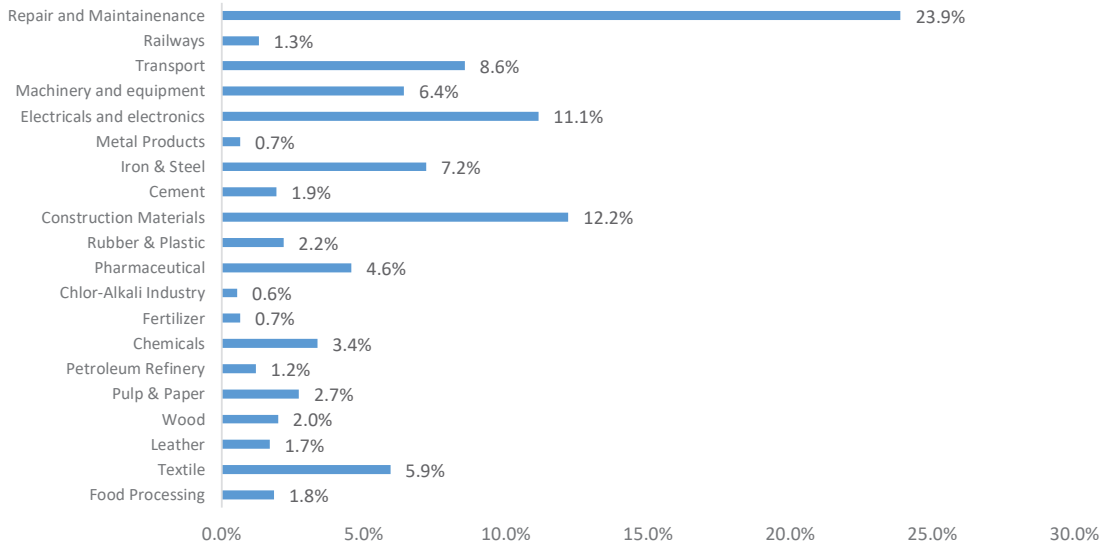
- The model follows a three-level production function. The top-level Constant Elasticity of Substitution (CES) production function includes the value added and intermediate inputs involved. The bottom-level function comprises the decomposed equations of value added and intermediate input equation.
- Also, the aforementioned production functions for sectors in MPSGE are defined in cost terms rather than quantities. Thus, the functional forms used in MPSGE (be it CES, Leontief, or Cobb-Douglas) are cost functions, not production functions. This is a key conceptual shift compared to traditional CGE formulations. The model thus solves for inputs that minimize cost for a given output level and price vector.
- The objective of the model is to assess the EE gains through skilled labour. In that vein, the production function has been modified to include a technical coefficient, a scaling factor to the common production function, as well as sector-specific technological components that reflect improvements in EE.
- Additionally, the refinement also includes modelling the dynamic reallocation of capital and savings across sectors each year to reflect economic adjustments over time, facilitating the estimation of employment and GDP gains throughout the periods.

The model is calibrated using a Social Accounting Matrix (SAM) with base year 2021-22, which is a comprehensive economy-wide data framework. The parameters involved in the model are assigned values from SAM, representing the aggregated values of demand, supply, transfers, trade and payments across 16 sectors in 3 regions (Tamil Nadu, Gujarat, and the Rest of India). The model results in a projected growth trajectory based on saving-investment trajectories, natural growth rate of population, exogenous final demand increase, etc.; that can further be used to compare and assess the overall economic impact of different scenarios on the economy and the welfare of the agents.

IV. Results

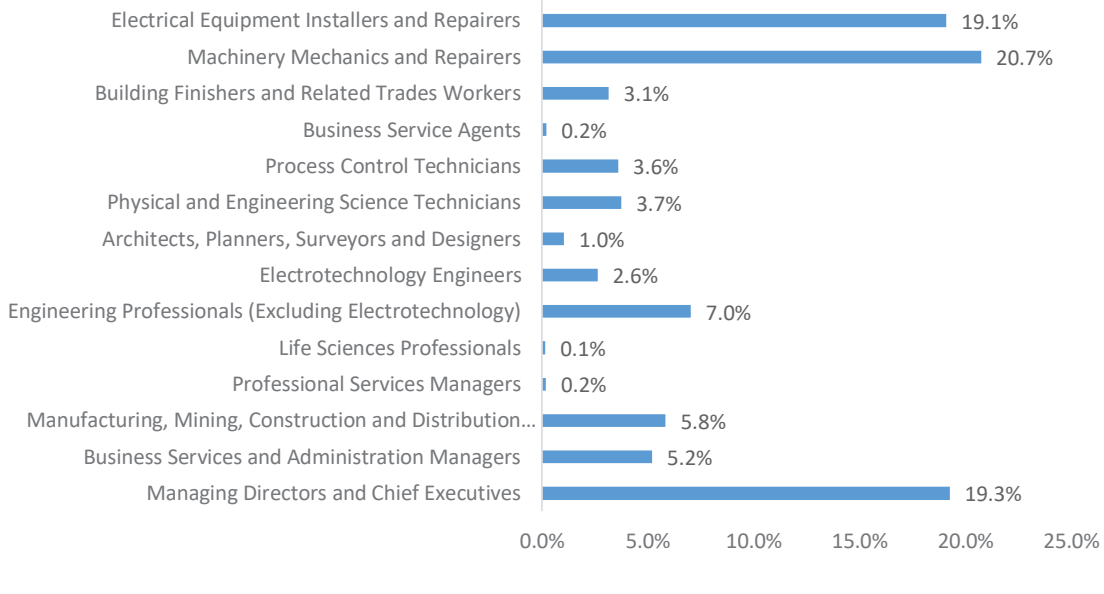
a. EE-relevant employment: Industry Groups

Figure 6: EE-relevant manufacturing employment - Industry Groups



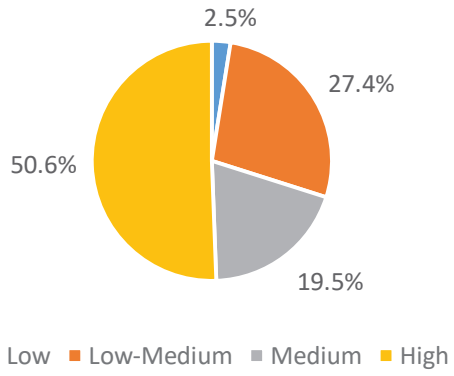
b. EE-relevant employment: Occupations

Figure 7: EE-relevant manufacturing employment: Occupations



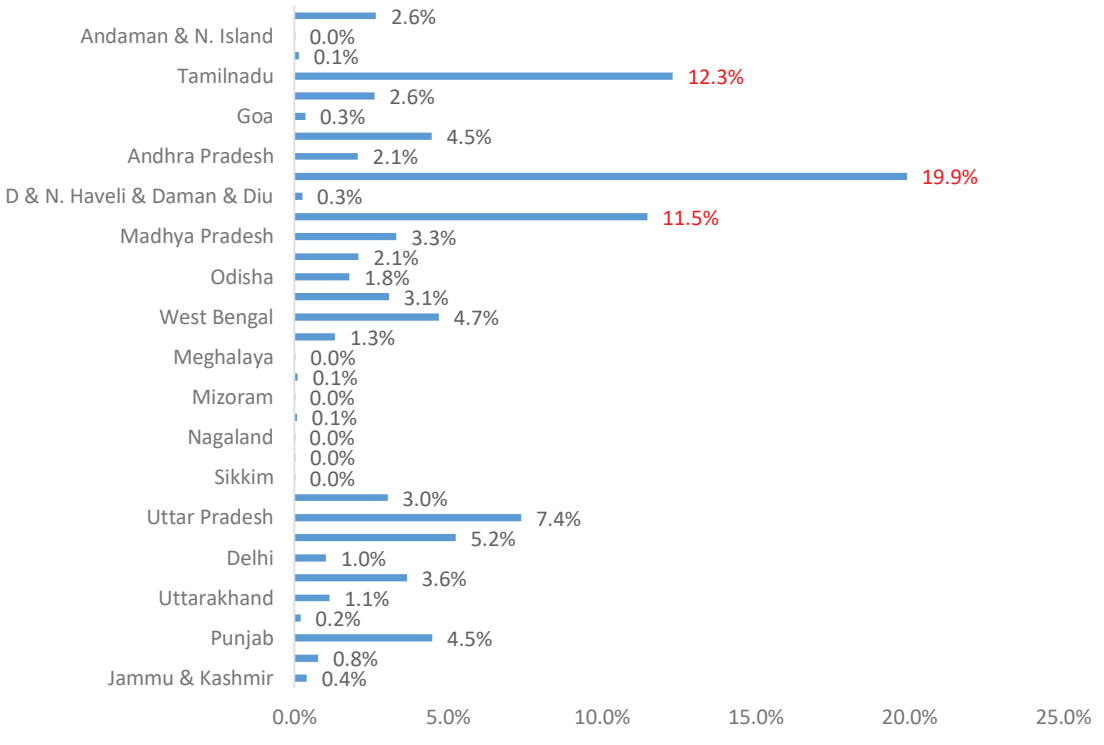
a. Skill-based disaggregation of EE-relevant employment

Figure 8: Skill based disaggregation of EE-relevant manufacturing employment



b. State level disaggregation

Figure 9: State level dis-aggregation of EE-relevant manufacturing employment



c. **Survey results**

Figure 10: Status of Energy Audits in the focus states

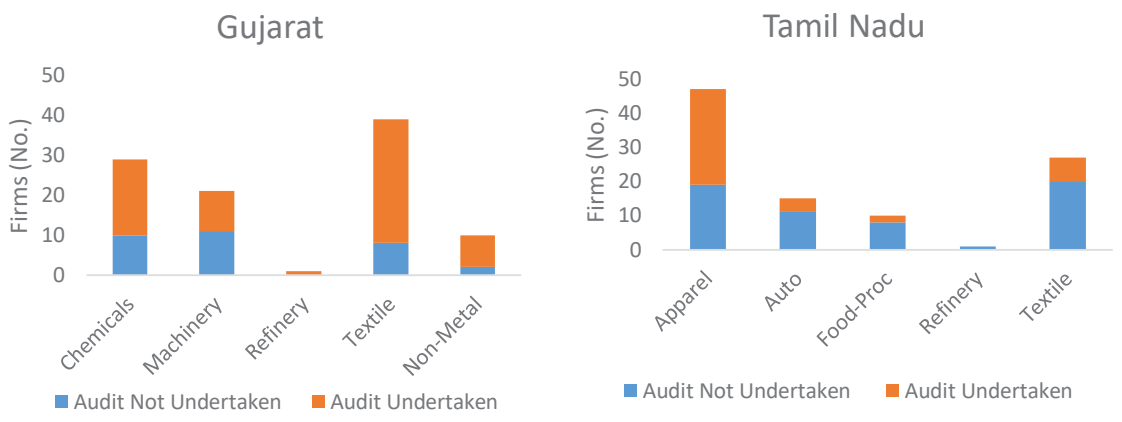


Figure 11: Barriers to Improvement in EE

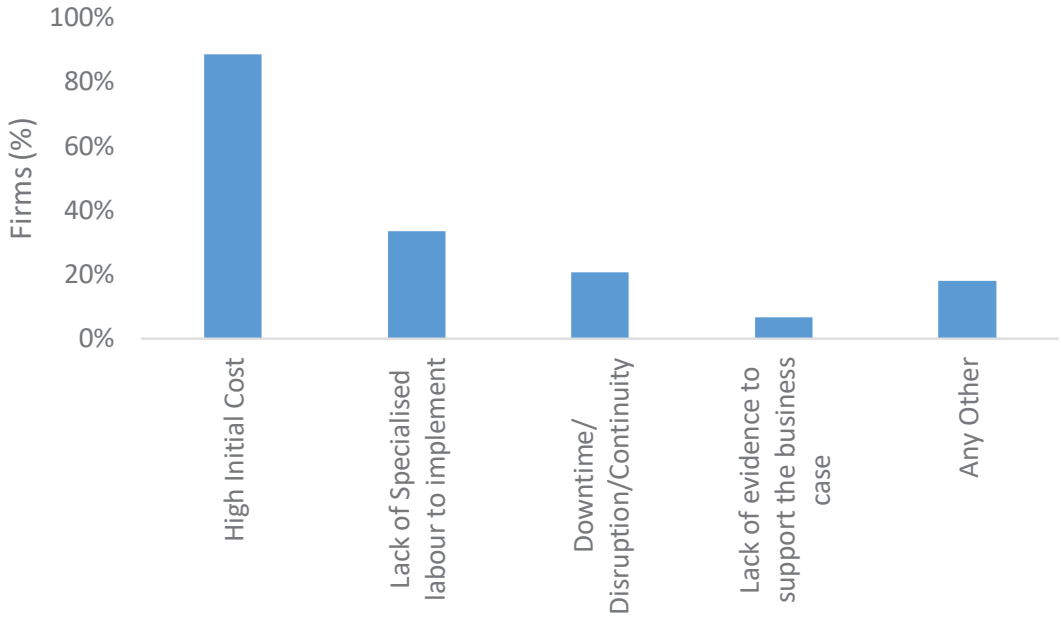


Figure 12: Factors Influencing EE Investment Patterns

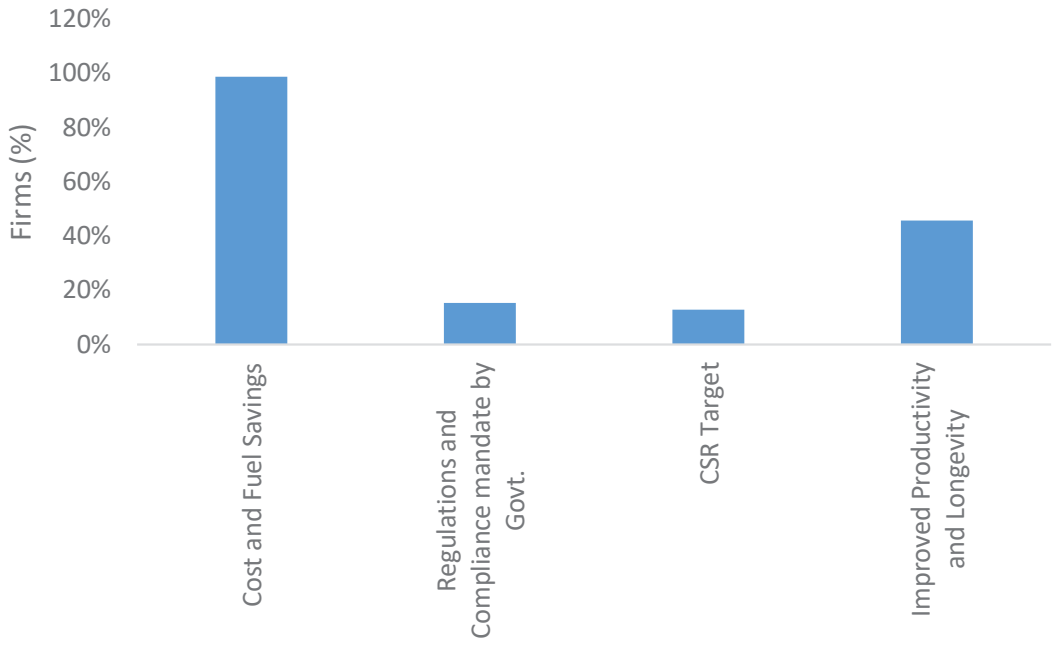
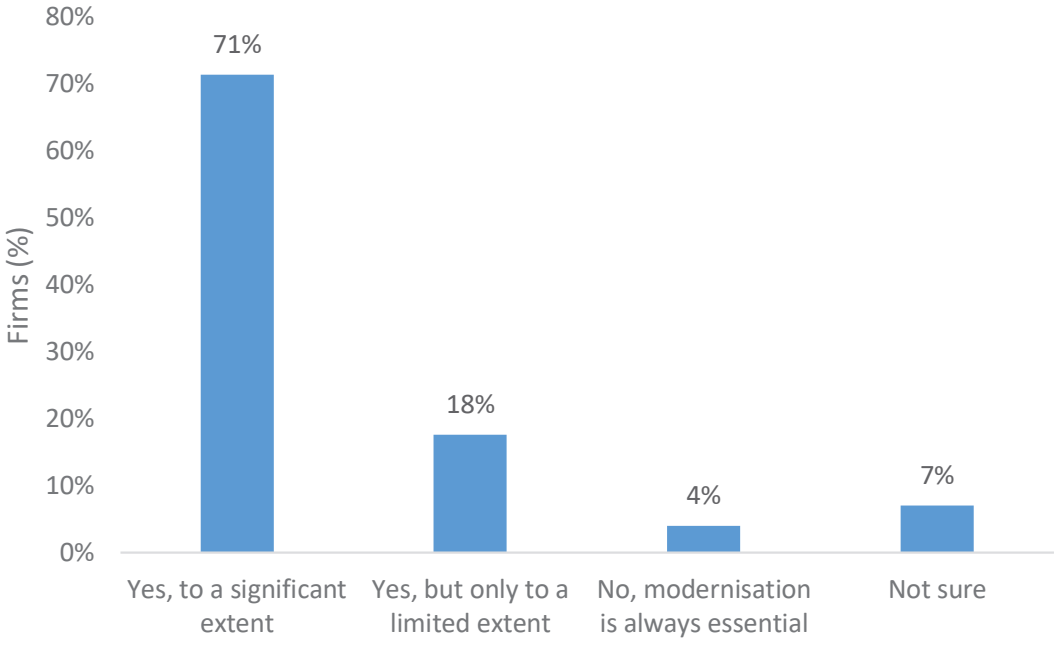


Figure 13: Influence of Trained Workforce on EE Measures



V. Key Takeaways

Findings from the Secondary Data Analysis

- **Substantial National Workforce Share:** Results indicate that 50.32 lakh workers are employed in EE-relevant manufacturing roles, making up about 8% of total manufacturing employment in India (2023–24), underscoring EE's growing significance in industrial employment.
- **State-wise Concentration of EE Jobs:** Maharashtra, Tamil Nadu, and Gujarat lead in EE-relevant manufacturing employment, reflecting their strong industrial ecosystems and potential for large-scale energy efficiency transformation.
- **Key Industry Groups:** Considerable share of EE-relevant employment was found to be contained in the industry groups of Repair and Maintenance (23.9%), Construction Materials (12.2%), and Electricals and Electronics (11.1%).
- **Key Occupational Profiles:** The top EE-relevant occupations include Machinery Mechanics and Repairers (20.7%), Managing Directors and Chief Executives (19.3%), and Electrical Equipment Installers and Repairers (19.1%), highlighting the mix of hands-on technical roles and strategic leadership involvement in EE.
- **Skill Composition Challenges Stereotypes:** Contrary to assumptions that EE employment is comprised of low-skilled workers, results indicate that the workforce is engaged in predominantly high-skilled (50.6%), followed by low-medium (27.4%) and medium-skilled (19.5%) roles, pointing to EE as a skill-intensive employment domain.
- **EE as a Catalyst for Industrial Transition:** The concentration of skilled EE employment in industrialized states and across technical roles positions EE as a strategic driver for sustainable and competitive manufacturing.

Findings from the Survey

- **State-wise Variation in Energy Audits:** 55% of firms conduct energy audits, with significant differences across states—69% in Gujarat vs. 41% in Tamil Nadu. Gujarat shows greater EE adoption in chemicals and textiles, while Tamil Nadu leads in the apparel sector.
- **Compliance-driven Audits:** Regulatory mandates like the Bureau of Energy Efficiency (BEE)'s Perform, Achieve and Trade (PAT) scheme drive audits in 60% of firms, but 1 in 5 firms only conduct audits when legally required to—highlighting a compliance-over-initiative mindset.
- **Firm Size Matters:** Large firms have dedicated EE budgets, while smaller firms rely on maintenance and equipment upgrades. Gujarat firms focus on cost and fuel savings; while firms in Tamil Nadu are more concerned about productivity and longevity.
- **Maintenance as an Efficiency Lever:** 98% of firms confirm that routine maintenance improves EE. Common practices include machinery upgrades (88%), component replacement (68%), and personnel retraining (42%).

- **Skill Gaps Hamper EE Adoption:** 89% of firms perceive retraining as a cost-effective EE strategy, however challenges remain in implementation due to gaps in practical skills among workers—recruited from government skilling programs. There is a need to revamp skilling with industry partnerships, especially for Micro, Small, and Medium Enterprises (MSMEs).
- The findings from both the secondary data analysis and the survey underscore the pivotal role of a skilled workforce in advancing industrial EE. While firms increasingly recognize the importance of workforce skilling, a persistent skills gap hinders effective EE implementation. Notably, 90% of firms not hiring from government-run skilling programs report that trainees lack practical, on-floor capabilities, and 30% highlight a mismatch between training curricula and the technical demands of industrial EE.
- This disconnect is particularly challenging for smaller firms, which, despite valuing EE, struggle to implement it due to limited access to both capital and skilled labour.
- State-level trends further reveal that although Gujarat, Tamil Nadu, and Maharashtra lead in EE-relevant manufacturing employment, EE awareness remains uneven across industrial groups, as is evident from audit practices.
- These insights indicate an urgent need for targeted policy interventions focused on curriculum reform, industry-led training, and improved skilling delivery to bridge existing gaps and facilitate broader EE adoption across India's industrial landscape.