



FUELLING EFFICIENCY: INDIA'S INDUSTRIAL ENERGY EFFICIENCY EMPLOYMENT AND SKILLS LANDSCAPE

SAJAL JAIN
DIYA DASGUPTA
SOMIT DASGUPTA
KUMAR ABHISHEK
SUNISHTHA YADAV
AMRITA GOLDAR

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Abstract

Energy efficiency (EE) in industries is critical in decoupling economic growth from environmental degradation by lowering energy intensity and enhancing competitiveness. As clean energy transitions accelerate globally, EE-relevant employment has shown steady growth, with some countries recognizing EE as one of the largest employment segments within the energy sector. The present paper provides first-of-its-kind existing stock estimates of EE-relevant employment in the product manufacturing sector for India, derived through the application of internationally established methodology. The analysis found 340 industry divisions at 5-digit National Industrial Classification (NIC) and 16 broad occupation groups under the National Classification of Occupation (NCO), as EE-relevant. Results indicate that 50.32 hundred thousand workers were employed in EE-relevant product manufacturing roles, accounting for about 8 percent of total manufacturing employment in India in 2023–24. As an EE-enabling catalyst, the paper notes the repair and maintenance segment to play a critical role. The largest contributing industry groups are formed by *Repair and Maintenance* (23.9 per cent), *Construction Materials* (12.2 per cent), and *Electricals and Electronics* (11.1 per cent). The analysis further highlights that EE-relevant employment is predominantly made up of high-skilled workforce (50.6 percent). To ensure a robust analysis, the paper employs a dual assessment framework comprising both output-based and task-based approaches, triangulated with data from the Periodic Labour Force Survey (PLFS). Additionally, select occupational tasks were validated via a mapping between the Occupational Information Network (O*NET) Green Economy Program occupation database and NCO.

Keywords: *energy efficiency, employment, skilling*

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Authors' email: sejaljain2412@gmail.com; ddasgupta@icrier.res.in; Dasguptas@icrier.res.in; kabhishhek@icrier.res.in; syadav@icrier.res.in; agoldar@icrier.res.in

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Fuelling Efficiency: India's Industrial Energy Efficiency Employment and Skills Landscape

Sajal Jain¹, Diya Dasgupta², Somit Dasgupta³, Kumar Abhishek⁴, Sunishtha Yadav⁵ and Amrita Goldar⁶

1. 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, poverty alleviation, promoting energy security, and much more. Much of the existing literature and policy thrust has been restricted to estimating the financial needs for clean energy transitions and employment generation from increased renewable energy (RE) penetration. However, there is an urgent need for policy discourse to highlight EE's contribution and potential to not just decarbonization objectives but also economic development via employment creation.

In line with the updated Nationally Determined Contribution (NDC) targets, India strives to achieve energy savings to the tune of 150 mtoe⁷ 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 2030.⁸

For the purpose of actualizing the national goals, states are being encouraged to proactively contribute toward this objective.⁹ Using the proportional shares of the erstwhile target (BEE 2019), the sectoral breakdown (refer to Figure 1) indicates that the highest energy saving share has been allocated to the industrial sector (54.7 percent), followed by transport (18.2 percent) and residential (13.9 percent) sectors. Moreover, as of 2023-24, the industrial sector accounts for more than half (~51 percent¹⁰) of the Total Final Energy Consumption (TFEC) in the country (MoSPI, 2025). This is indicative of the critical need to focus on the energy intensity of the industrial sector as well as assess the potential of energy-efficient practices and technologies. Concerted efforts to this effect are being taken, as is evident from the

¹ Former Research Fellow, Indian Council for Research on International Economic Relations (ICRIER)

² Research Fellow, ICRIER

³ Visiting Professor, ICRIER

⁴ Consultant, ICRIER

⁵ Former Research Associate, ICRIER

⁶ Professor, ICRIER

⁷ Million tonnes of oil equivalent (mtoe)

⁸ Available at: https://sansad.in/getFile/annex/267/AU2713_vEX07t.pdf?source=pgars. Accessed on 12 April, 2025.

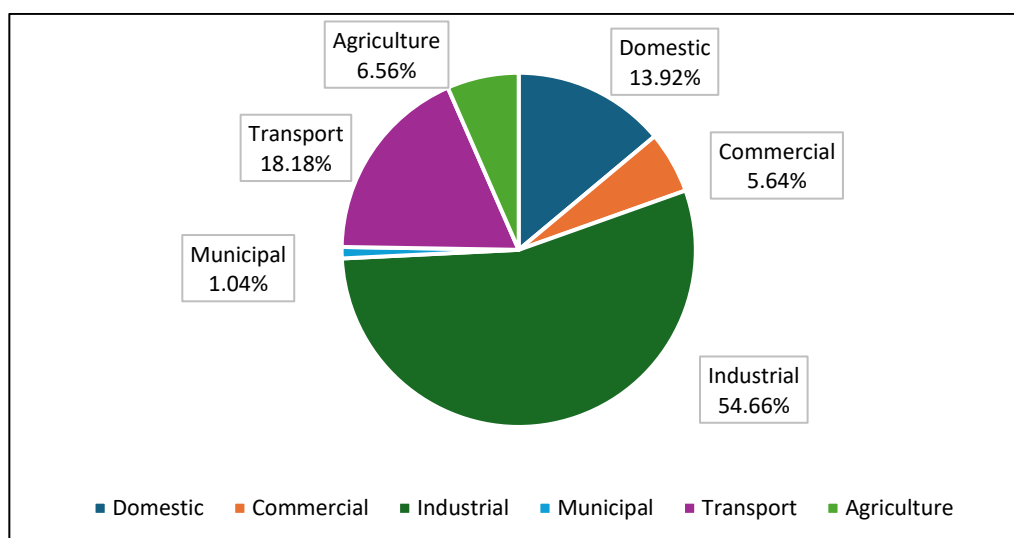
⁹ Available at: https://www.business-standard.com/article/economy-policy/centre-asks-states-to-expedite-energy-efficiency-activities-on-mission-mode-123022600380_1.html. Accessed on 12 April, 2025.

¹⁰ Provisional figures as per Energy Balance of India 2023-24.

progress made under the Perform, Achieve and Trade (PAT) scheme, the establishment of an Advanced Industrial Technology Demonstration Centre (AITDC), initiatives promoting EE and RE in Micro, Small and Medium Enterprise (MSME) clusters, etc.

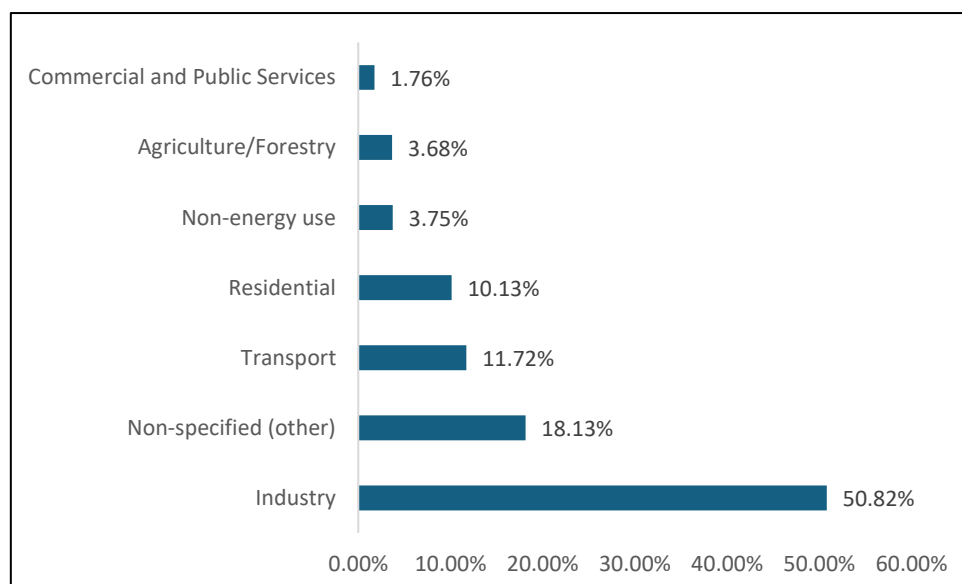
State Energy Efficiency Action Plans (SEEAPs) are also being formulated at the sub-national levels. On-ground implementation of these targets will assume the availability of a skilled workforce.

Figure 1: Sectoral Distribution of Updated Energy Saving Target



Source: Adapted from BEE (2019)

Figure 2: Total Final Energy Consumption (TFEC): 2023-24 (P)



Source: Authors' construction using MoSPI (2025)

Against this backdrop, the present paper focuses on a first-of-its-kind assessment of

the existing stock of EE-relevant employment in the Indian product

manufacturing sector, adopting an employment estimation methodology that is comparable with international standards. It does not estimate the incremental employment effects of EE investments or employment multipliers. It also estimates prevalent skill levels in the EE industrial product manufacturing employment landscape and elaborates on the need for enhancing skill profiles.

2. Policy Relevance and 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 RE penetration, the potential of EE is often underestimated. There is an urgent need for the policy discourse to highlight EE's contribution, not only to decarbonization but also to economic development through employment creation.

The present paper caters to two critical policy areas, i.e., employment generation and skill development in the niche subset of EE-relevant product manufacturing and the repair and maintenance segment. However, it is important to note that employment classified under the repair and maintenance segment should be interpreted as potentially EE-enabling in nature, rather than as having an exclusively EE-specific orientation, given there exists limitations in distinguishing general maintenance activities from those directly undertaken for EE improvements.

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).¹¹ The program aligns well with the paper's emphasis on estimating EE-relevant employment at the granular level of tasks and occupations and identifying existing skill shortfalls. These insights can provide critical policy recommendations towards planning and designing skilling programs at the national as well as the state level. 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.

The assessment goes beyond prevalent RE assessments to explore the underexplored avenue of EE-employment. Building on the narrative that EE serves as a catalyst for clean energy transitions, the paper explores the EE product manufacturing and the repair and maintenance segment's employment potential in the country and attempts to answer the following research questions:

- a. What is the potential of EE-relevant employment in India's industrial product manufacturing sector? As an EE-enabling catalyst, does the repair and maintenance segment play a critical role? What are the dominant industries, tasks, and occupations that carry an EE

¹¹ 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.

component or potential in the assessment sub-sector?

- b. What are the prevalent skill levels of the workforce as part of the assessed EE-relevant ecosystem? How can these be leveraged to their maximum potential when planning skilling programs for EE?

The structure of the rest of the paper is as follows. **Section III** provides an overview of existing studies with respect to employment estimation and skill-based decomposition, while **Section IV** elaborates on the adopted methodology. Results have been presented in **Section V**, followed by the conclusion and areas of future research in **Section VI**.

3. Literature Review

When it comes to studying the macroeconomic effects on account of an increase in renewable generation, adoption of EE measures, and initiating the circular economy, one finds that there is close interaction. According to Heideier et al. (2020), the macro parameters could be economic (power rates and utility revenues), environmental (Greenhouse Gas (GHG) emissions), political (tax collection), and social (job creation). While authors have included both RE and EE in their analyses, the emphasis has been more on the former. The commonly used routes of studying these impacts include either adopting an input-output (IO) model (Kaiser, et al., (2005); (Peltier, 2017)), a computable general equilibrium (CGE) model (Bataille & Melton, (2017); Allan, et al., (2007)), analytical econometric methods (Chen, et al., (2023); Costantini, et al., (2018)) or using

employment factors¹² (Rutovitz et al., (2021), Lehr et al., (2012)).

3.1 International Context

Stavropoulos and Burger (2020) analysed thirty papers in terms of the net employment impacts of RE and EE, with twenty-three papers catering to the former and only four dealing with EE. Moreover, eighteen studies used the IO method whereas CGE accounted for seven studies and the remaining used analytical methods. Whether adoption of RE and EE measures lead to an increase in employment is contentious. While most of the studies do seem to indicate that there is a positive relationship (Füllemann, et al., (2020); Hartwig, et al., (2017); Barrett, et al., (2002)), however, there is evidence that suggests this may not always be the case (Bohringer, et al., (2013); Cameron & Zwaan, (2015)). Costantini, et al., (2018) carried out a sub-sectoral study of 15 European nations and came to the conclusion that EE actually reduces employment, especially in energy intensive industries. In contrast, Bell (2012), highlights that since EE measures lead to more construction activity, there is an addition to employment. The study has estimated that an investment of \$1 million in EE creates 20.3 jobs while the national average is only 17.3. Similarly, Chen, et al., (2023) have estimated that a 1 percent reduction in energy intensity leads to an increase in employment growth by 2 percent. Fulleman, et al., (2019) too were of the view that there is a positive correlation between energy transition and EE with employment. The authors came to the

¹² Primarily used for RE employment estimation

conclusion that jobs are created more on the consumption side rather than production and therefore are here to stay. Some case studies conducted for the United States (US), Germany, and Portugal also show a positive correlation between EE and employment (Anderson, et al., (2014); Kuckshinrichs, et al., (2010); Mirasgedis, et al., (2014), Oliveira, et al., (2014)). It is worth mentioning that verification of job creation is actually a difficult task and hence the use of models like the CGE is imperative (Bell, 2014). Besides, the results arrived at are a function of the methodology adopted which explains these diverse results (Stavropoulos & Burger, 2020). While there seems to be a reasonable amount of work for the developed countries, research on developing countries is hard to come by (Chen, et al., (2023)).

Employment can be broadly classified into three types - direct, indirect, and induced. While the impact on direct and indirect employment is positive meaning an increase in employment, nothing, a priori, can be said of induced employment. It is possible that the induced effect could not only be negative but also outweigh the positive effect of the other two types of employment (Sooriyaarachchi, et al., (2015); Mu, et al., (2018)). When EE measures are introduced, there is a decrease in prices which leaves consumers with a surplus income which can be used to buy goods and services from other sectors. What is important is the estimation of net jobs rather than gross jobs. To give an example, while investment in renewable generation creates employment, there is a loss of jobs when it comes to fossil fuel mining. Furthermore, the effect could be

different across sectors. Sievers, et al., (2019) have indicated that while there is positive growth in the value addition of sectors like construction and real estate, in the case of sectors like mining, it could be negative. Additionally, the time period under study could affect the results. Stavropoulos and Burger (2020) have opined that studies with a shorter time horizon are generally less optimistic about employment creation. The authors also state that policy reports usually overstate the positive effect on employment compared to academic studies.

However, at the same time, literature also highlights the vitality of EE and its contribution to employment creation. It is pertinent to note that if the economy is in a state of less than full employment, investments in EE act like a Keynesian multiplier which adds to employment (Blyth, et al., 2014). The results would not be the same if the economy is already in a state of full employment and fresh investments at this stage would only crowd out private investments. Similarly, cities with low efficiency and low employment rates benefit more than flourishing cities. The authors also point out that enhanced trade and technological progress magnify the positive effect EE has on employment. Equally important are factors, such as scale of implementation, regional differences, government policies, and overall economic context (Chen, et al., 2023). Moreover, it is quite possible that job growth may take place in the entire value chain or may be concentrated only in construction, operation and maintenance, implying that job creation varies across countries (Sooriyaarachchi, et al., 2015).

A few authors also allude to the existence of rebound effects of EE, wherein improvements in EE may result in increased energy consumption, thereby offsetting a part of the energy savings (also known as Jevons' paradox) (Gillingham, et al., (2016); Ehrhardt-Martinez & Laitner, (2010)). The idea behind the same is that EE results in lower energy costs, thereby stimulating output and leading to economy-wide adjustments, including employment generation. For instance, using a recursive dynamic CGE model, Bataille & Melton (2017) investigate the impact of EE improvements in Canada between 2002-2012. The results indicate that EE led to an increase in GDP and employment by 2 percent and 2.5 percent respectively. The authors also found evidence of structural shifts in the economy wherein productive capital was reallocated away from energy supply sectors towards other sectors that were typically more labour-intensive. Thus, while sectors such as natural gas, hydro-based electricity and refining witnessed an output contraction, the rest of the economy (being relatively more labour intensive) registered a growth. Similarly, Du, et al., (2020), examined the impact of a 10 percent improvement in transportation EE in China, using a multi-sectoral CGE model. The authors found that EE was accompanied by a positive impact on GDP, investment and welfare. Specifically in the road transport segment, EE improvements were followed by reductions in cost of transport services, thereby leading to a fall in production costs of other industries, ultimately stimulating output, employment and GDP in the economy.

3.2 Indian Context

With specific reference to India, studies estimating EE employment have been fairly limited and those that are available report conflicting results. While many have focussed on exploring the relation between labour intensity and energy intensity (Sahu & Narayanan (2013); Kumar, et al., (2023); Soni, et al., (2017)), some have looked at the factors influencing energy intensity trends (Jain & Kaur (2023)), while still, others have delved into estimating employment generated per unit of investment (Pollin & Chakraborty (2015); Azad & Chakraborty (2018)). These studies can be largely bucketed into two categories, i.e., those adopting econometric methods for empirical validation and those using input-output frameworks for estimating employment. The sections that follow, provide a brief overview of some of these studies.

Econometric Methods:

Sahu & Narayanan (2013) examined (a) whether firms that are more labor-intensive are also more energy-intensive and (b) whether energy and labor serve as substitutes for each other. The study focused on the pulp and paper industry in India and made use of unit-level data sourced from the Center for Monitoring Indian Economy (CMIE) spanning 1992 – 2000. The econometric exercise revealed that while small and large labor-intensive firms are also energy-intensive, medium labor-intensive firms consume comparatively less energy. Additionally, the results indicated that labor intensity is non-linearly related to energy intensity (inverted U-shaped curve), thereby suggesting the possibility of substituting

between the two, after having exceeded the threshold.

Kumar, et al. (2023) explored the factors determining energy intensity in the case of manufacturing industries and the power sector in India, using aggregated firm-level data from 2010-2021. Employing the panel quantile regression method, the results indicated that factors such as labor intensity, profit after tax intensity, repair and maintenance of plant and machinery intensity, and outsourced intensity were positive and significantly impacted energy intensity. With specific reference to labor intensity, it was found that the positive relation with the dependent variable held true for all quantiles barring the 50th, thereby indicating that the labor intensity of aggregated firms raises energy intensity. The authors opine that the rise in energy intensity may be linked to poor labor productivity and employment of laborers with low skill levels. Therefore, as employment increases, it may be accompanied by higher energy intensity and decreased EE. A possible solution to circumvent such a predicament could be proper skill development and training programs that aim to improve technological capabilities and help augment efficiency. Such a positive relation between labor intensity and energy intensity has also been reported by Soni, et al. (2017), who analyse factors influencing the latter with respect to the Indian aluminium, iron and steel, cement, textile, and fertilizer industries.

On the other hand, Jain & Kaur (2023) assessed the factors influencing energy intensity trends and levels in the Indian metallic industry during 2007-2017, and

found conflicting results. The authors grouped a sample of 41 firms into three categories namely those that exhibit increasing, decreasing, and relatively constant energy intensity trends (EIT), and carried out an econometric analysis employing (a) multinomial logistic and (b) pooled random effects GLS regression models. Results from the analysis revealed that as the labor intensity, size, and age of a firm increases, so does the probability that the said firm would belong to the decreasing EIT category of metal firms as compared to the reference category of increasing EIT. Additionally, it was also found that a rise in labor intensity, size, and age of a firm tends to reduce the energy intensity levels as far as the Indian metallic industry is concerned.

Mahapatra & Irfan (2023) explored the asymmetric effects of EE on employment in India. Their analysis made use of multi-sectoral panel data (2000-2014) and employed both a stochastic frontier approach (SFA) and a non-linear panel autoregressive distribution lag model. These aforementioned econometric techniques were used to estimate sectoral EE and investigate its asymmetric impact on employment. The authors found that in the long run, a positive shock on EE negatively impacts employment, while a negative shock generated no statistically significant results. As regards the short run, the analysis suggested that a positive shock on EE decreased employment while a negative shock had the opposite impact. The authors opined that the negative impact may be a result of a shortage of skilled workforce required for adopting energy-efficient technologies.

Input-Output Framework:

Using an IO framework, Pollin & Chakraborty (2015) examined the relationship between economic growth, employment, and emission reduction in the context of India. They estimated both direct and indirect employment under two scenarios. While scenario 1 assumes that even with the rise in investments in RE and EE the domestic content remains stable, scenario 2 assumes an increase in imported inputs to support the expanding RE and EE sectors. The results suggest that the combined RE and EE investments can generate double the jobs as compared to similar spending on fossil fuel industries. Specifically for EE, under scenario 1, building retrofits, industrial efficiency, and grid upgrades were found to generate 280, 193, and 173 jobs respectively per spending of USD 1 million for the year 2009-10. The corresponding figures under scenario 2 stood at 279, 190, and 169 jobs per spending of USD 1 million. A similar study by Azad & Chakraborty (2018) highlights that an investment of USD 1 million per annum in green energy programs can generate 197 jobs as opposed to 82 jobs in fossil fuel programs in India. These figures were calculated for 2011-12, include both direct and indirect jobs, and have been arrived at after assigning a weight of 33 percent and 67 percent to jobs created under EE and RE respectively. Within the EE program, an investment of USD 1 million was found to generate the highest number of jobs under weatherization¹³ (218.4), followed by public

transportation (150.2), industrial EE (149.6), and smart grids (125.9).

3.3 Skilling

While the preceding sections elucidate the findings of existing studies on the demand for EE-relevant labour, the parallel aspect of the supply of skilled labour (determining the feasibility to meet the said demand) is equally necessary. Skill development is known to serve as a cushion to withstand any transitory disruptions that may occur while moving toward a low-carbon economy (ILO, 2019). According to the International Energy Agency (2022), there has been a considerable shift in the global energy labour market, wherein more than half of the workforce is engaged in the clean energy sector. It is expected that the aforementioned trend would be accentuated further with a concomitant rise in demand for skilled workers. In particular, given that the skill sets of workers are likely to vary across industries, tasks, and locations, firms may face a shortage of workers with the requisite skills in a particular region. Overcoming such a challenge would require either developing fresh educational programs, vocational training, and certificate courses or up-skilling and re-skilling the workforce.

Studies have found that job displacements resulting from technological transitions tend to be costlier for workers particularly when skills are occupation-specific and non-transferable. That is, relocation costs are contingent upon skill similarities across

¹³ Weatherization can be defined as activity engaging in home improvements that aids to reduce energy use such as moisture control, air sealing, ventilation, and upgrades to insulation, doors and windows, with one of the major benefits of the same being increased energy efficiency (McAden, 2023).

occupations (Poletaev & Robinson, (2008); Gathmann & Schönberg, (2010)). While some authors posit that much of the required re-training in a green economy can take place on-the-job (Bowen, et al., (2018)), others are of the opinion that a green economic transition necessitates the development of new skills, qualifications, and competencies that are associated with the emergence of new markets (Shanghi & Sharma (2014); Aceleanu, et al., (2015)).

In the Indian context, a number of studies have delved into the skilling landscape as far as RE is concerned (Chaturvedi, et al., (2024); Tyagi, et al., (2023); Kuldeep, et al., 2019); (SCGJ (2016)). They document skill trends across RE sources, assess the skill gaps, and provide recommendations to bridge the same. Some of the policy suggestions include expanding state-level institutional capacity, developing sectoral skilling programs, promoting local-level skill development for leveraging the employment potential in the RE sector, providing support to the workforce currently engaged in conventional sectors via upskilling, reskilling, and re-certification initiatives, and so on.

In sum, while a substantial body of literature exists on the employment impacts of RE, research on EE-relevant employment remains limited and fragmented. In the Indian context, the evidence base is even thinner, with most analyses concentrated on the relationship between energy and labour intensity or aggregate job multipliers, offering little clarity on sectoral distribution, occupational profiles, or skill requirements. Moreover, while the demand side of EE-relevant labour has been examined to some degree, the supply-side dynamics, in

particular the availability and development of relevant skills, remain underexplored. Against this backdrop, the present paper addresses these critical gaps by providing systematic estimates of EE-relevant employment for India, mapping industry, occupational, and skill-level distributions.

4. Assessment Methodology

This section elaborates on the detailed methodology that was developed for the assessment of EE-relevant manufacturing employment in the country, disaggregated at the skill level. The analysis explores a granular estimation of EE-relevant employment across tasks and occupations to highlight skill shortfalls.

4.1 Definition: EE-relevant Employment

Before elaborating on the detailed assessment methodology, it is critical to first define the concept of ‘EE-relevant’ employment used in the analysis. As mentioned in the preceding literature review section, the concept of RE employment has more widespread acceptance in contrast to the employment assessment for EE. Although the idea does exist, there are multiple definitions of the same across the globe, given the far-reaching impacts of the sector. However, the multi-definition structure makes the employment assessments more open to interpretations, and at the same time also makes it challenging to assess the exact size and scope of the EE workforce (IEA, 2023). Further, while the broad classification of EE sectors that are spread across the economy are relatively easier to identify and define,

identification of the exact division of industries and occupations in those sectors is more complex, owing to the aforementioned lack of an accepted definition of what constitutes EE.

With an emphasis on end-use efficiency, the analysis in this paper focuses on a subset of the entire EE-relevant employment in the country. It defines EE employment as employment in '*EE-relevant industries*' that encompass manufacturing, production, and installation of products that support enhancing EE, along with the repair and maintenance of such products. This definition is based on the concept of EE jobs in the *United States (US) Energy and Employment Survey* report, albeit they define it for a broader set of industrial activities. The US faces a comparable challenge of a lack of specific codes dedicated to the EE sector. To illustrate, the US definition of EE employment encompasses employment in the manufacturing of ENERGY STAR-labelled products, akin to the BEE star ratings of products in India (Keyser et al., 2022).

Due to this indirect linkage, the present paper defines the obtained set of estimates as *EE-relevant* employment. This definition aids the estimation of an actionable workforce base for EE, supporting a skill analysis. Furthermore, aligning with global methodologies, the definition helps to ensure inclusivity in the assessment. The obtained estimates, although indirect, will play a crucial role in the formulation of effective policies and plans for the energy transition. The detailed methodology of the assessment of EE-relevant employment is discussed in the following sections.

4.2 Methodology

EE forms a part of the clean sector, which in turn forms a subset of the broader set of green sectors. The estimation methodology of EE-relevant employment draws on the concept of green employment assessment. Building on international frameworks, the paper adopts the methodology as described in Granata and Posadas (2024) and World Bank (2023) for an analysis of green employment in Vietnam. It adopts the prescribed routes of 'task-based' and 'output-based' assessments for EE-relevant employment estimation.

It is important to highlight that with the focus on EE product manufacturing and the related repair and maintenance segment, the analysis delves deeper into the production side of EE products by restricting the assessment to the economy's manufacturing sector and the repair and maintenance segment. EE involves using less energy to perform the same task or produce the same output. There are two main approaches that can be adopted to attain greater EE. The *first approach* involves deploying energy-efficient products, which include replacing existing inefficient products with new, efficient ones (e.g., replacing Compact Fluorescent Lamp (CFL) bulbs with Light Emitting Diode (LED) bulbs), or improving the EE of products in current use. The *second approach* focuses on process innovation, incorporating measures such as regular maintenance and upkeep, energy audits, energy management systems, optimized heat transfer and industrial process optimization and captures occupations involved in such tasks. By applying a task and occupation-based lens,

focusing on the manufacturing of EE products and repair and maintenance, the analysis integrates both perspectives. However, it is critical to mention that the process management components such as repair and maintenance, are considered only in relation to the identified subset of EE products and equipment included within the employment assessment, rather than representing all process management activities across the broader manufacturing sector.

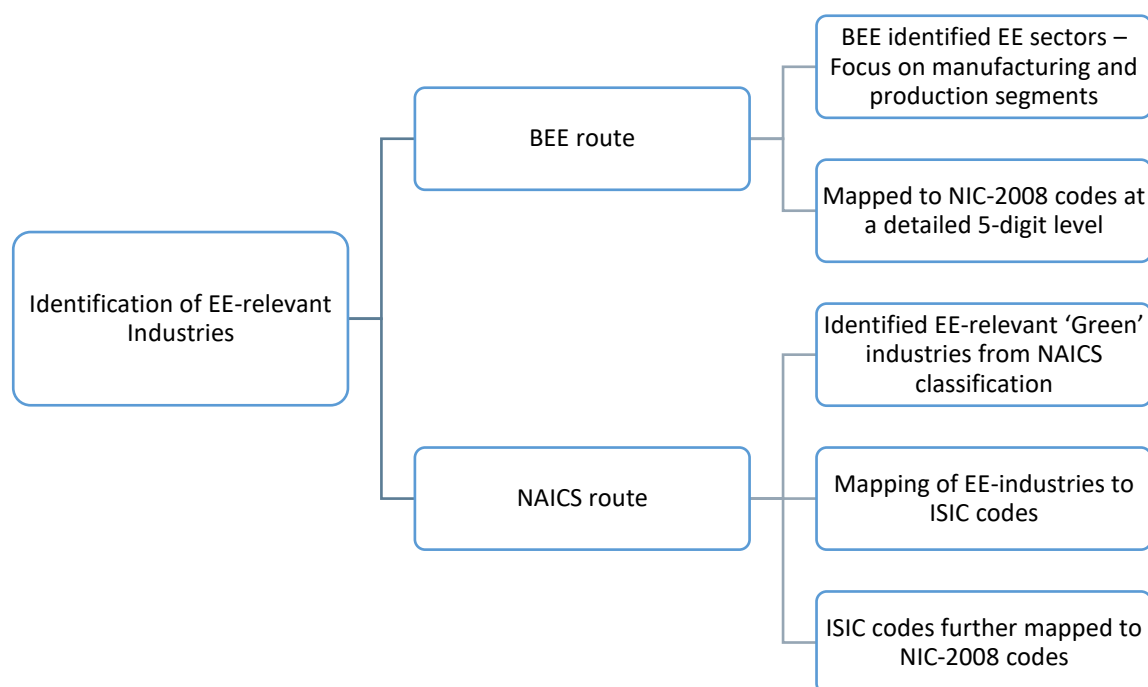
Further, it is important to note that employment classified under the repair and maintenance segment should be interpreted as potentially EE-enabling in nature, rather than as having an exclusively EE-specific orientation, given the limitations in distinguishing general maintenance activities from those directly undertaken for EE improvements.

4.2.1 Output-based Assessment

Objective: Identification and creation of a pool of EE-relevant industries for India

The output-based approach focuses on the final products and services and the extent of their contribution to reducing adverse environmental impacts and/or conserving the environment. The concept encapsulates the exploration of specific sectors that produce goods (or outputs) that can be considered beneficial for the environment (World Bank, 2023). In our application of this method, an assessment was undertaken with respect to the identification of industries that contribute towards EE. It is imperative to mention that there exists no direct or indirect categorisation with respect to EE in the National Industrial Classification (NIC) code list; hence, for the identification of the same, two routes were adopted, as illustrated in Figure 3.

Figure 3: Employment Assessment Approach - Output-based Assessment

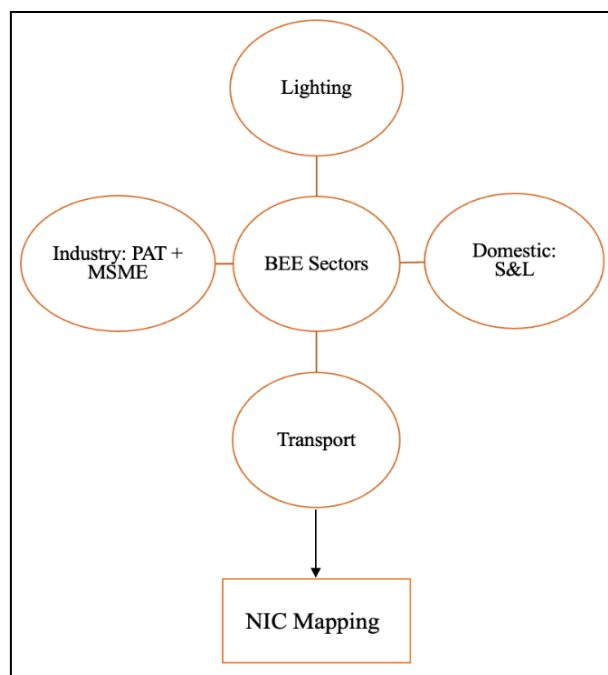


Source: Authors' Construction

The first route involved the identification of EE industries via EE sectors or the Bureau of Energy Efficiency (BEE) route. The BEE identifies several sectors as EE sectors, or sectors wherein there exists scope for increasing EE. These include the Perform, Achieve, and Trade (PAT) scheme sectors, the building sector, etc., that symbolise industries that have been identified to exhibit energy-saving potential. At the same time, it is important to note that the analysis does not treat energy-intensive industries as EE sectors. Rather, EE relevance is determined at the level of occupations and tasks within selected industries, ensuring that only those roles associated with EE-related activities are included in the employment estimates. Utilising the latest BEE *Impact of Energy Efficiency Measures* report, a list of all such sectors was compiled along with the sub-segment classifications

under each (DTTILLP, 2023). Focusing on the manufacturing, production, and repair and maintenance segments, four sectors from the identified pool under BEE were chosen, as indicated in Figure 4. Each sub-segment for these selected sectors was then analysed in detail to map all relevant industry codes. This mapping was undertaken at a detailed 5-digit level of the NIC codes. The major criterion for this classification was dependent on the energy use or energy consumption linked to industries, with a specific focus on the manufacturing, production, and repair and maintenance fields. This, in turn, involved substantial background research into the energy use and established EE potential of each classified sector and its sub-segments. Each industry division was meticulously analysed to identify any EE linkage and thus EE-relevant industries.

Figure 4: EE Sectors - BEE Route



Source: Authors' Construction

The second route was formed by the mapping of EE industries through the exploration of the North American Industry Classification System 2007 (NAICS 2007) of green industries, or the NAICS route. The NAICS is a US Bureau of Labor Statistics (BLS) classification, containing a detailed mapping of green industries with a disaggregation into EE and other industries. These identified EE industries were mapped from the NAICS codes to the International Standard Classification of Industry Revision 4th (ISIC) codes at a 4-digit level. This was facilitated by the official crosswalk between the two codes, available on the BLS website, with some modifications. The ISIC codes were then mapped to the NIC codes at a detailed 5-digit level, allowing for global comparability and improved alignment with an international green employment structure.

The combination of these two routes helped to create a pool of identified EE-relevant industries. Leveraging both BEE (national) and NAICS (international) classifications ensured a comprehensive list of EE-relevant industries in India. The list of 3-digit industry codes along with the EEGs has been provided in Annexure I.

4.2.2 Task-based Assessment

Objective: Identification and creation of a pool of EE-relevant occupations for India

The task-based approach involves the exploration of the nature of various occupations and their task content. It also helps to establish linkages with specific skill requirements to perform the occupational role better (Granata and Posadas, 2024). In

our application of the same, it involved the identification of specific industrial EE-relevant tasks or roles.

This comprised a thorough exploration of the Occupational Information Network (O*NET) Green Economy Program (O*NET GEP) occupation database. The O*NET is the key source of occupational information in the US and is globally recognized and used by researchers in the domain. The O*NET GEP was formulated for the purpose of identifying occupations that are likely to be impacted by green economic activities and technologies (Dierdorff et al., 2009; Dierdorff et al., 2011). It is pertinent to mention that O*NET GEP was used as a task-identification and structuring tool, not as a direct representation of Indian employment execution. The analysis does not assume equivalence in technology sophistication. Instead, EE relevance is derived from the nature of tasks (e.g., energy audits, maintenance for efficiency, energy management, process optimisation) rather than from the production environment in which those tasks are performed. These task linkages were further refined through keyword screening, exclusion of RE-specific tasks, and validation using field insights from Indian MSME clusters in Gujarat and Tamil Nadu (details below). The employment estimates so derived thus reflect EE-relevant employment potential, not identical task execution.

O*NET GEP covers a wide variety of topics or sub-sectors. Under the green program, occupations were assessed to establish their relevance and contribution to the EE process. Specifically, the database provides detailed information pertaining to 314

unique occupations spread across 72 green topics. A master sheet comprising all unique occupations, along with their associated tasks categorization based on their EE relevance was prepared. For each task against every occupation, an in-depth analysis was conducted to assess its relevance to EE. This process was guided by several criteria: (a) keyword identification (e.g., 'energy savings,' 'energy efficient/efficiency,' 'energy conservation', 'energy management', etc.), (b) exclusion of tasks involving RE¹⁴, and (c) insights gathered during fieldwork in Gujarat and Tamil Nadu (e.g., the inclusion of tasks involving repair and maintenance of industrial machinery and equipment). A sample example has been presented in Annexure II.

The next step involved the estimation of the Energy Efficiency Task Intensity index (EETI). The concept of EETI draws inspiration from the concept of the Green Task Intensity (GTI) index, wherein the GTI index measures the green task content of occupations and is defined as the proportion of green tasks in an occupation (Granata and Posadas, 2024). Adapting the same for EE estimates, the EETI index is defined as the proportion of EE-relevant tasks in an occupation in comparison to the entire set of tasks or responsibilities of that occupation. More precisely,

$$EETI = \frac{\text{Number of EE-relevant tasks in an occupation}}{\text{Total number of tasks in an occupation}} * 100$$

Post the EETI calculations, a mapping of identified EE occupations from O*NET GEP to the National Classification of Occupation (NCO) 2015 was undertaken. In the absence of a comparable task-level occupations documentation for India, the EETI values derived using O*NET were applied to the corresponding occupation classification mapped using NCO 2015 as a proxy. To assess the suitability of this assumption, a mapping of the tasks listed in O*NET GEP with those listed in the National Classification of Occupations (2015) Vol II – A was undertaken. This exercise was carried out for 5 occupations with different EETI scores¹⁵ that has been presented in Annexure III. It was found that O*NET task descriptions are more granular and disaggregate activities that are described in broader terms under NCO. Further, the disaggregation in O*NET also covers aspects not covered under NCO but are relevant to EE. All tasks mentioned under NCO find either a direct mention in O*NET or are indirectly covered. Thus, no NCO-recognised task falls outside the scope of O*NET. Accordingly, NCO occupations were included where the mapped task descriptions aligned with the identified EE task content. It is acknowledged, however, that the broader nature of NCO occupational classifications may lead to some degree of overestimation, as specialised EE roles cannot always be isolated within aggregated occupational groups. The resulting estimates should therefore be interpreted as EE-

¹⁴ There are existing studies that document RE employment; however, EE employment has remained relatively less explored, specifically in the Indian context. Including RE in this estimation would dilute the core objective of the study of solely focusing on EE-relevant employment, which has been identified as a gap in the literature. Moreover, it would also lead to double-counting of employment.

¹⁵ These include (i) Energy Auditor (90.48%), (ii) HVAC Mechanics and Installers (70%), (iii) Power Plant Operator (30%) (iv) Automotive Engineering Technician (27.8%), and (v) Nuclear Engineer (20%).

relevant employment potential rather than precise EE-specific employment.

It is pertinent to mention that the NCO mapping exercise involved the creation of an integrated concordance between multiple

code groups to finally arrive at NCO 2015, which is prevalent in India (Figure 5). The combination of these steps resulted in the creation of the pool of identified EE-relevant occupations for India.

Figure 5: Concordances across numerous rounds of Standard Occupation Classification (SOC)



Note: International Standard Classification of Occupations (ISCO)

Source: Authors' construction

4.2.3 Integration with Periodic Labour Force Survey (PLFS) Database

Objective: Obtaining EE-relevant employment estimates in India for 2023-24

The two aforementioned approaches were then combined to estimate the EE-relevant employment in EE industries (the identified set as per NIC 2008; section 4.2.1) for only EE occupations (the identified set as per NCO 2015; section 4.2.2). These two approaches complement each other and bridge gaps in individual coverage. The output-based approach can help identify EE industries but does not contribute much to the skilling aspect on its own. However, when combined with the task-based approach, the analysis can be widened, and informed insights can be drawn.

The task-based approach is useful to inform the skill policy component. It helps to delve deeper into occupation categories, identifying the nature of job tasks and skill

requirements to help plan the energy transition policies better. The identification of specific tasks contributes to existing EE literature in the country through occupation profiling for the sector. Such occupational profiles will, in turn, play a crucial role in policymaking as far as skilling and training requirements are concerned for developing a more resilient workforce that is capable of withstanding the incoming energy transition (World Bank, 2023).

The output-based approach, on the other hand, helps to identify particular industries that are observed to carry EE components and potential. It helps to contribute towards sectoral or industrial policy through the comprehensive identification of EE industries. Employment assessments in such industries will add to the literature through the identification of EE-relevant industries as well as help towards understanding the existing sector dynamics in terms of labour demand and skilling needs (World Bank, 2023).

The two approaches were thus applied together to quantify EE-relevant employment using microdata, through the PLFS database. It is pertinent to mention that the analysis covers only direct employment and does not include indirect or induced employment in the EE sector.

4.2.4 Skill-based Assessment

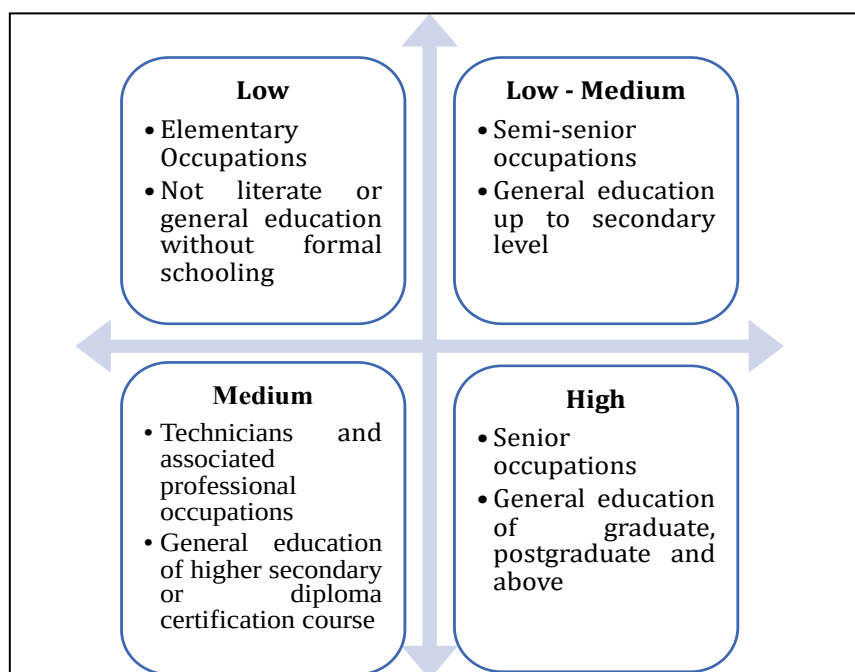
Objective: Development of a skill-based disaggregation of EE employment estimates

As discussed previously, the analysis explores the employment prospects in the EE sector as well as the existing skilling structure. Skills play an indispensable role in fostering a productive workforce and are fundamental to its development. The vitality of a skilled workforce has been time and again emphasized by numerous studies as well as government policy programs, thus

making it an essential component to be paired with employment assessments.

A skill-based disaggregation of EE-relevant employment estimates will aid in assessing the prevalent skill patterns and thus contribute towards effective and efficient framing of training modules as well as skill policies for the sector. The skill component in the analysis was based on a combination of occupation and general education parameters, to reflect both the nature of the job and qualifications of the workforce. The usage of educational attainment to identify skill levels is based on the universal acceptance of education as one of the most important determinants for the development of skill. Four different skill levels or categories were defined, as demonstrated in Figure 6.

Figure 6: Skill Categorisation



Source: Authors' construction

Specifics of each category have been elaborated on below:

- *Low skill (Category 1)*: comprises elementary occupations, coupled with workers who are either not literate or have achieved general education status without formal schooling.
- *Low-medium skill (Category 2)*: comprises occupations in the semi-senior category like craft and related trade workers, plant and machine operators, etc., and/or with general education up to secondary level.
- *Medium skill (Category 3)*: includes occupation categories of associate professionals, clerks, and service and shop workers, coupled with a general education status of higher secondary or diploma certification course.
- *High skill (Category 4)*: comprises the set of personnel in senior occupations, including professionals, legislators, senior officials, and managers, combined with a general education status of graduate, postgraduate, and above.

The occupation classification in this skill categorisation was derived from the mapping of skill levels based on educational requirements under the International Standard Classification of Occupation (ISCO)-2008, with the national counterpart by NCO-2015.

The four-tier structure enables a deeper understanding of skill mismatches and training needs. A more detailed classification helps capture the true skill structure across industrial sectors, especially in EE-linked roles, where certain functions may not fit neatly into standard categories. The final value for the skill variable accounts for both the factors (occupation¹⁶ and education), but is determined by the one with the higher rank. Essentially, this implies that if a person is skilled in either occupation or education, the higher skill level prevails, and thus, skills may be acquired through either formal education or occupational experience, thereby classifying individuals accordingly.

5. Results

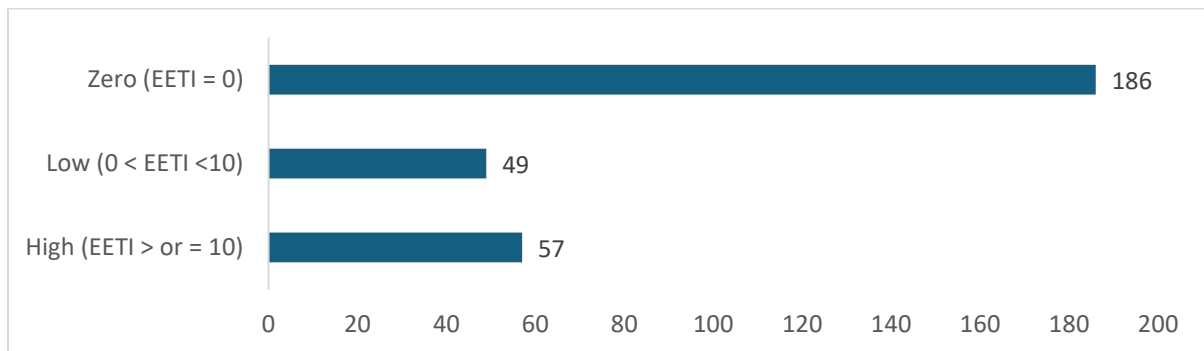
The identification exercise of the pool of EE-relevant industries revealed a set of 340 industry divisions at a detailed 5-digit level in the NIC code structure to be EE-relevant, for the considered year of 2023-24 of the PLFS database. This broad pool of 340 EE-relevant industries caters to diverse groups. Thus, for ease of operations, all identified EE-relevant industries were further grouped together to form 20 EE groups (EEGs). These include Food Processing, Textile, Leather, Wood, Pulp & Paper, Petroleum Refinery, Chemicals, Fertilizer, Chlor-Alkali Industry, Pharmaceutical, Rubber & Plastic, Construction Materials, Cement, Iron & Steel, Metal Products, Electricals and electronics, Machinery and equipment, Transport, Railways, and Repair and Maintenance.

¹⁶ It is crucial to highlight that the applicability of technical education was also explored in the formation of the skill variable. A cross-tabulation of technical education and general education revealed several overlaps between the two for the high skill categories (graduates, post-graduates, and above). In essence, the framed skill variable thus captures both general and technical education.

Similarly, the identification and creation of the pool of EE-relevant occupations using the task-based assessment highlighted noteworthy results. Out of the 314 unique occupations, 22 were excluded as these included all residual occupations not covered elsewhere and did not have any tasks listed against them. Figure 7 depicts the results of the EETI calculation exercise. Specifically, 36 percent of the occupations fell in the category of *high* and *low* EETI (i.e.,

had an $EETI \geq 10$ and $0 < EETI < 10$, respectively), while 64 percent had an EETI score of 0. For occupations with non-zero EETI scores, the average value stood at 17.3 percent, with the minimum and maximum being 2.8 percent and 90.5 percent, respectively. For the 292 occupations, a benchmark criterion of $EETI \geq 10$ percent was applied to identify the final pool of EE-relevant occupations.

Figure 7: Frequency Distribution of EETI Index¹⁷

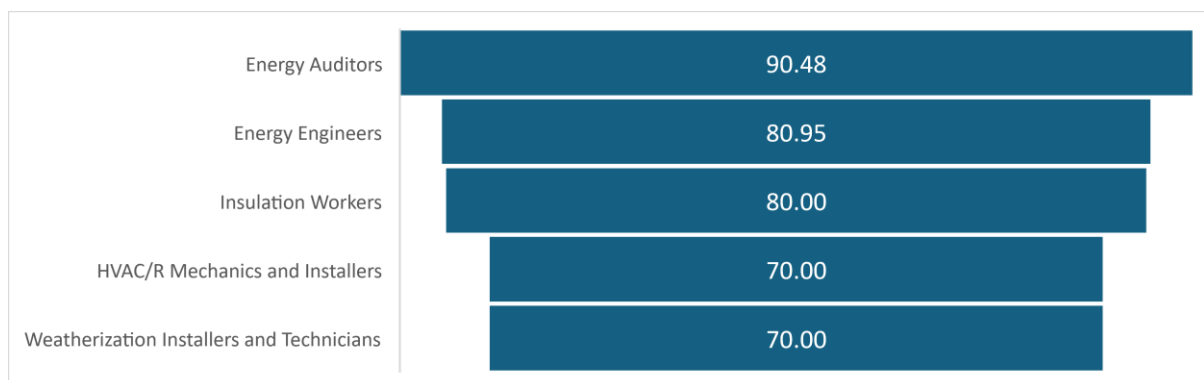


Source: Authors' construction

The top five occupations with the highest EETI score included (1) *Energy auditors*; (2) *Energy engineers (except wind and solar)*; (3) *Insulation workers, floor, ceiling, and wall*;

(4) *Heating, air conditioning, and refrigeration (HVAC-R) mechanics and installers*; and (5) *Weatherization installers and technicians*.

Figure 8: Top 5 Occupations and Corresponding EETI Scores



Source: Authors' construction

¹⁷ Excludes 22 occupations that did not have any tasks listed against them

The O*NET occupations were then mapped to the NCO classification to arrive at the corresponding occupation set for India. It is pertinent to note that the 292 unique occupations could only be mapped at a broad 3 digit-level under the NCO classification, as facilitated by the PLFS secondary database that was used for employment estimation. This essentially

implies that the identified occupation codes were mapped to a comparatively broader set that aggregates several detailed codes (hence occupations) together. The final exercise resulted in the mapping of 57 EE-relevant occupations from the O*NET database to 16 broad occupation groups under the NCO classification. This mapping has been presented in Table 1.

Table 1: Mapping of occupations in O*NET with NCO 2015

NCO	NCO Description	O*NET-SOC 2019 Title
112	Managing Directors and Chief Executives	Chief Sustainability Officers
121	Business Services and Administration Managers	Compliance Managers
132	Manufacturing, Mining, Construction, and Distribution Managers	Hydroelectric Production Managers
		Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation
		Geothermal Production Managers
		Construction Managers
		Transportation, Storage, and Distribution Managers
134	Professional Services Managers	General and Operations Managers
213	Life Sciences Professionals	Environmental Scientists and Specialists, Including Health
		Sustainability Specialists
		Industrial Ecologists
		Environmental Restoration Planners
		Environmental Science and Protection Technicians, Including Health
214	Engineering Professionals (Excluding Electrotechnology)	Energy Engineers, Except Wind and Solar
		Mechanical Engineers
		Photonics Engineers
		Mechatronics Engineers
		Automotive Engineers
		Civil Engineers
		Transportation Engineers
		Fuel Cell Engineers
		Aerospace Engineers
		Nuclear Engineers
		Architectural and Engineering Managers
		Nanosystems Engineers
		Environmental Engineers
215	Electrotechnology Engineers	Electronics Engineers, Except Computer
		Electrical Engineers
		Telecommunications Engineering Specialists
216		Architects, Except Landscape and Naval

NCO	NCO Description	O*NET-SOC 2019 Title
	Architects, Planners, Surveyors and Designers	Urban and Regional Planners
263	Social and Religious Professionals	Environmental Economists
311	Physical and Engineering Science Technicians	Energy Auditors
		Heating, Air Conditioning, and Refrigeration Mechanics and Installers
		Construction and Building Inspectors
		Automotive Engineering Technicians
		Electrical and Electronic Engineering Technologists and Technicians
		Aerospace Engineering and Operations Technologists and Technicians
		Geothermal Technicians
		Electro-Mechanical and Mechatronics Technologists and Technicians
		Logistics Engineers
		Photonics Technicians
		Nuclear Technicians
		Industrial Engineering Technologists and Technicians
		Mechanical Engineering Technologists and Technicians
313	Process Control Technicians	Hydroelectric Plant Technicians
		Power Plant Operators
		Power Distributors and Dispatchers
		Water and Wastewater Treatment Plant and System Operators
333	Business Service Agents	Freight Forwarders
712	Building Finishers and Related Trades Workers	Insulation Workers, Floor, Ceiling, and Wall
		Roofers
		Plumbers, Pipefitters, and Steamfitters
723	Machinery Mechanics and Repairers	Farm Equipment Mechanics and Service Technicians
741	Electrical Equipment Installers and Repairers	Weatherization Installers and Technicians
		Electricians
931	Mining and Construction Labourers	Helpers--Installation, Maintenance, and Repair Workers

Source: Authors' construction

Results indicated that the total EE-relevant manufacturing employment in the country for 2023-24 stands at about 50.32 hundred thousand across all EEGs. It is interesting to note that EE-relevant employment formed a share of about 8 percent of the total manufacturing employment in the country for the same period. This signals the vital role that EE can play towards the macroeconomic

benefits of employment creation in the manufacturing sector itself. The International Energy Agency's (IEA) report on World Energy Employment for 2024 highlights that India's employment in EE has grown by 4 percent year-on-year from 2019 to 2023, driven by several state-led initiatives (IEA, 2025). Drawing parallels to the analysis, the report also discussed that

the clean energy manufacturing workforce has been increasing rapidly in the country.

The presence of sizeable EE-relevant employment is indicative of the substantial role that EE can be expected to play towards the transformation of the industrial landscape and its energy requirements.

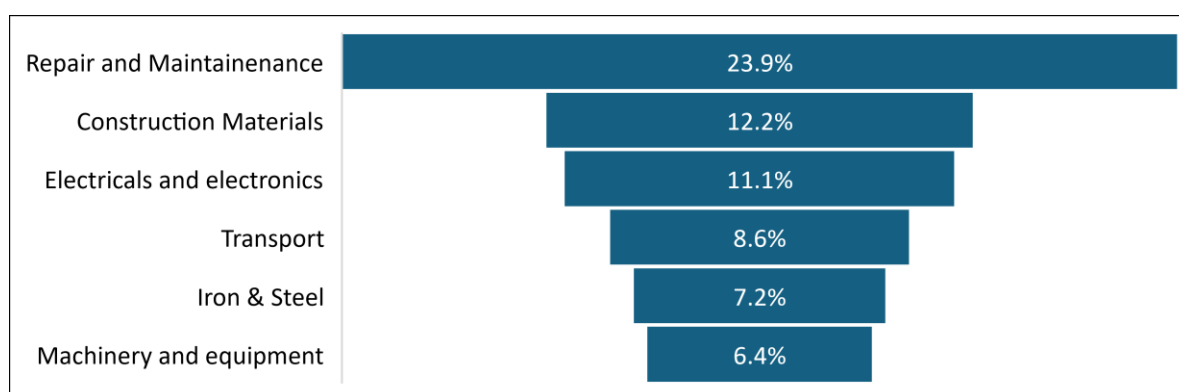
It is critical to mention that in the identification and assessment of EE-relevant employment, the *EE relevance* is attributed only to identified EE-relevant occupations and tasks within selected EE-relevant industries, and these are subsequently aggregated to estimate employment across EE groups and sectors. At the same time, the analysis is constrained by the limitations of available classification systems. The NIC codes do not provide technology or process-specific identifiers (e.g., conventional vs. zigzag kilns within brick manufacturing), and NCO codes similarly lack sufficient granularity to distinguish workers engaged in efficiency-enhancing practices from those in standard processes within the same occupation. Thus, the assessment cannot be assumed to clearly distinct between *energy-*

intensive activities and *energy-efficient practices*. Recognising these constraints, the estimates are best interpreted as EE-enabling employment, rather than exclusively “clean or green” employment. The estimates thus may represent an upper-bound estimate, potentially including workers engaged in conventional production within EE-targeted industries.

5.1 Industry Groups

With respect to the industry groups or EEGs, a considerable share of EE-relevant manufacturing employment was found to be contained in the categories of *repair and maintenance* (23.9 percent), *construction materials* (12.2 percent), and *electricals and electronics* (11.1 percent), amongst the 20 groups. The top six industry groups were formed by these three, in addition to *transport, iron and steel*, and *machinery and equipment* manufacturing. In fact, showcasing a wide coverage, these six groups together represent about 70 percent of the total EE-relevant manufacturing employment. Figure 9 represents these dominant EEGs.

Figure 9: Dominant industry groups in EE-relevant manufacturing employment: All India



Source: Authors' construction

In tandem with the identified BEE sectors, the EE-relevant manufacturing employment dominance covers industries that are known to carry EE components such as manufacturing of consumer electronics, electric wires, cables, etc., repair and maintenance of industrial machinery, manufacturing of bricks, glass (construction material), manufacturing of various type of vehicles, including electric, rail, etc.

The dominance of repair and maintenance group is reflective of an important insight into the current structure of India's industrial EE landscape. This distribution suggests that in the near term, EE-linked employment is driven more by operational efficiency improvements, focused on optimising and extending the performance of existing industrial capital stock. This in turn, implies lesser reliance on capital expenditure associated with the manufacture and deployment of new energy-efficient machinery. Such a pattern reflects the prevalence of legacy equipment and cost-sensitive investment behaviour, particularly among MSMEs, where efficiency gains are more readily achieved through improved maintenance practices, retrofits, and process optimisation. A similar pattern was observed in our ground survey in the states of Gujarat and Tamil Nadu.¹⁸

From a policy perspective, this underscores the role of repair and maintenance sector as EE-enabling activities that support the life-extension and resource-efficiency objectives central to circular-economy frameworks. It also highlights the immediate potential for

employment creation and skill development within EE-related framework, even as longer-term transitions toward more capital-intensive efficiency technologies gradually unfold.

Further, the sectoral distribution of EE-relevant employment also reveals an important distinction between upstream energy-intensive industries and downstream EE-enabling manufacturing segments. While upstream sectors such as cement, iron and steel, and other basic materials remain central targets of EE interventions due to their high energy intensity, they are typically characterised by relatively lower labour intensity and limited incremental employment generation from efficiency improvements. In contrast, downstream segments, most notably *Electricals and Electronics*, which accounts for 11.1 percent of total EE-relevant employment, exhibit higher labour intensity and manufacture of equipment that enable efficiency improvements across multiple industrial applications. The results therefore suggest that while upstream sectors are critical for achieving aggregate energy and emissions reductions, downstream EE-enabling manufacturing plays a more pronounced role in employment generation, particularly in the context of scaling energy-efficient technologies across Indian industry.

5.2 Occupation Groups

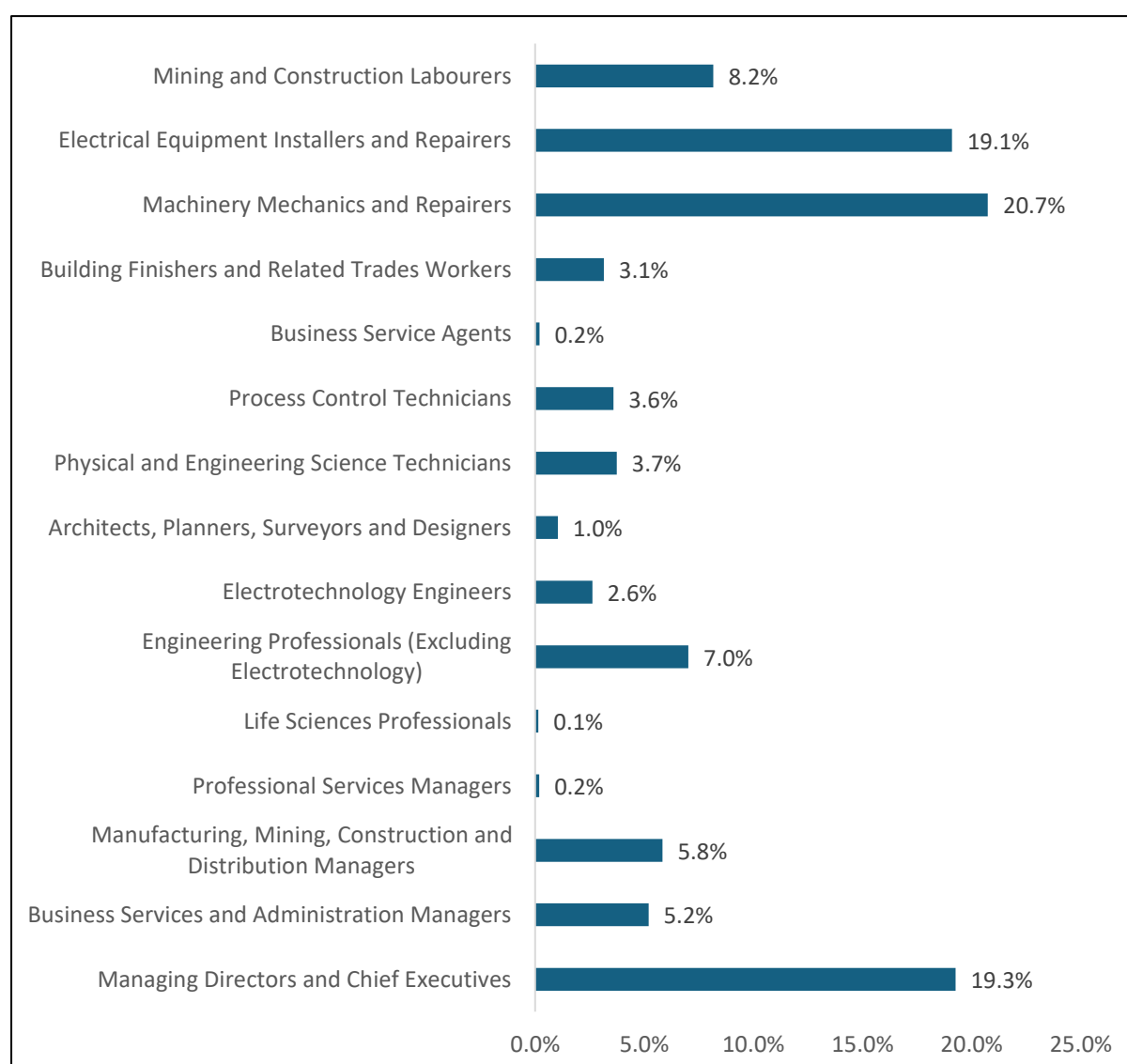
The EE-relevant occupation analysis further provided noteworthy insights. As indicated in Figure 10, three occupations represented

¹⁸ Read more: Abhishek, K., Yadav, S., Jain, S., Dasgupta, D., & Goldar, A. (2025). *Barriers, Drivers, and Skilling Needs for Energy Efficiency in Indian Manufacturing* (No. 53). Indian Council for Research on International Economic Relations (ICRIER), New Delhi, India. https://icrier.org/pdf/pb53_Barriers-Drivers-Skilling-Needs-for-Energy-Efficiency.pdf

more than half of the EE-relevant employment (about 60 percent), showcasing a mix of both senior and medium-level designations. These were formed by *Machinery Mechanics and Repairers* (20.7 percent), *Managing Directors and Chief Executives* (19.3 percent), and *Electrical Equipment Installers and Repairers* (19.1 percent). The significant role of mechanics and installers in EE is expected, given the maintenance requirements of electrical

equipment to ensure its efficiency. The role of senior designations such as managing directors and chief executives, in turn, indicates the awareness level amongst the top management, with respect to EE. Furthermore, the decisions for increasing or inducing EE in the production process for any industry will involve high-level decision-making and management or implementation capabilities that usually rest with the senior designations.

Figure 10: Dominant Occupations in EE-relevant manufacturing employment: All India



Source: Authors' construction

These results also corroborate the previous findings within the industry groups, wherein *Repair and Maintenance* and *Electricals and Electronics* were dominant. Ensuring the efficiency of production processes involves installation as well as recurring maintenance of the machinery engaged, thereby assigning a crucial role to electrical installers and repairers.

The occupation group results highlighted a strong presence of both technical and leadership roles in the EE sector, indicative of a skill-intensive nature of EE employment. Furthermore, one of the key advantages of the occupation group analysis in the sector was highlighted in the reflection of growing specialisation in EE-relevant sectors. The data assessment demonstrated the need for customized skilling approach and support policies to boost EE-led employment. Targeted skill development, particularly in repair, electronics, and technical services,

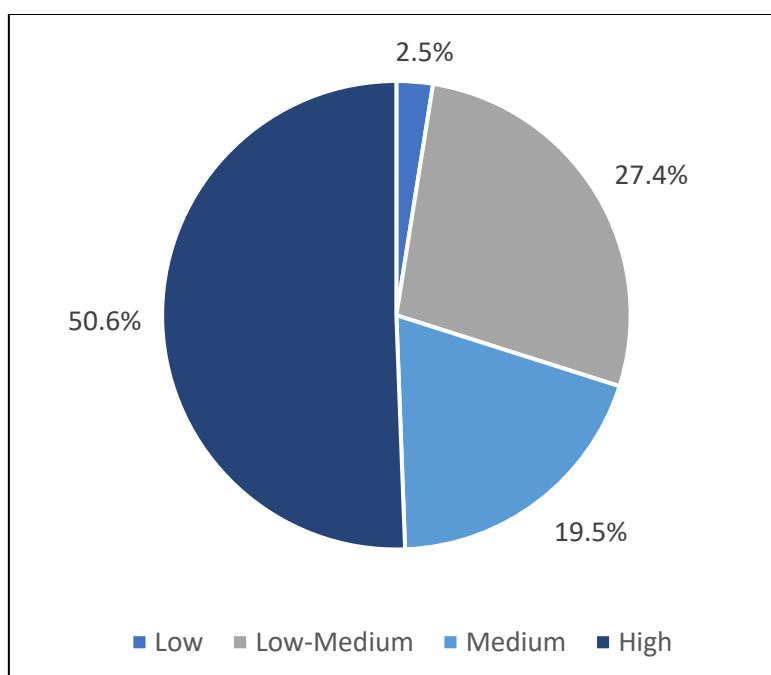
can help the employment potential of the workforce in the sector.

5.3 Skill-based Assessment

In order to better inform the skilling policy landscape of the EE sector, it is essential to understand the existing skilling structure. This component of the results section elaborates on the skill-based assessment results, as obtained from the secondary database analysis.

Of the total estimated EE-relevant employment, the aforementioned skill categories-wise employment disaggregation showcases interesting results. The data reveals that at the all-India level EE workforce is largely engaged in high-skilled roles (50.6 percent), followed by low-medium (27.4 percent) and medium-skilled (19.5 percent) occupations, as demonstrated in Figure 11.

Figure 11: Skill-based disaggregation of EE-relevant manufacturing employment: All India



Source: Authors' Construction

The results suggest that about 70 percent of the estimated EE workforce falls into the high or medium skill brackets. It is further interesting to note that the share of low-skilled workers is, in fact, extremely low at 2.5 per cent. In contrast to the general convention that EE generally houses low-skilled employees, this result offers a fresh perspective on the existing and changing patterns of employment while also pointing towards the high potential of EE employment. It can be assumed that, given the adopted definition of the skill variable, EE-relevant employment does not rely heavily on unskilled labour. Even if the occupation group appears low-skilled, the workers actually performing the tasks might have sufficient education to push their skill level classification upwards.

It is critical to discuss the results obtained for the high-skilled roles. This significant estimated share is partly influenced by the classification framework of the NCO 2015, under which managerial roles such as Managing Directors and Chief Executives (NCO 112) are categorised as high-skilled based on decision-making responsibility and organisational complexity rather than solely on technical expertise. In the Indian MSME context, these roles may often correspond to owner-proprietors or workshop managers whose engagement with EE is primarily through investment decisions, technology adoption, and operational oversight, rather than direct technical implementation. Accordingly, the high-skilled EE-relevant category may be interpreted as comprising both managerial or decision-making roles and professional roles, with the latter representing the critical area for targeted

capacity-building and skilling interventions to support deeper EE outcomes.

Another interesting observation is the significant proportion of the workforce in the low-medium band, at 27.4 percent. These essentially represent the middle tier, undertaking the heavy implementation work such as appliance servicing, installation, etc. This set carries the potential to move up the skill ladder with adequate training programs. These are workers with some formal education and will benefit the most from short-term vocational and re-skilling programs.

These results indicate the strong presence of technically demanding employment opportunities in the EE sector. The advanced diverse industrial base in the country, as well as the availability of higher education infrastructure, can be assumed to play a pivotal role in the skilling structure. The low-medium heavy concentration indicates a quantum of workers who have the potential for skill upgradation through targeted training mechanisms.

Overall, these results indicate that EE-relevant employment is an attraction hub for workers with higher education or more technical occupations, such as engineers, technicians, etc. This hints at the presence of strong analytical abilities and technical expertise in the sector. There also exists a significant segment of workers who can up-skill, revealing a vital role for skilling programs in the EE sector. Thus, the skill distribution pattern in the EE sector does display a presence of skill shortfalls. EE-relevant employment is not uniform, spanning a broad spectrum of expertise.

There are indications of a dual demand for skills to ensure an optimal mix. For advanced skills to support modern EE technologies and for foundational, entry-level skills to broaden adoption and implementation. This is important for multiple functions across the EE sector, including operational, maintenance, and on-ground implementation.

6. Conclusion and Future Research Areas

To sum up, the assessment undertaken as part of this paper underscores the critical role of EE sectors in employment generation, while also drawing attention to the challenges in defining and capturing the full scope of the EE workforce. These include:

- **Substantial National Workforce Share:** Results indicate that 50.32 hundred thousand workers were employed in EE-relevant manufacturing roles, making up about 8 percent of total manufacturing employment in India in 2023–24, underscoring EE’s growing significance in industrial employment.
- **Key Industry Groups:** A considerable share of EE-relevant employment was found to be contained in the industry groups of Repair and Maintenance (23.9 per cent), Construction Materials (12.2 per cent), and Electricals and Electronics (11.1 per cent).
- **Key Occupational Profiles:** The top EE-relevant occupations include Machinery Mechanics and Repairers (20.7 percent), Managing Directors and Chief Executives (19.3 percent), and Electrical Equipment Installers and Repairers (19.1 percent),

highlighting the mix of 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 percent), followed by low-medium (27.4 percent) and medium-skilled (19.5 percent) roles, pointing to EE as a skill-intensive employment domain.
- **Skill Shortfalls Persist:** Drawing on the occupational and skill-level distribution results, the analysis indicates that EE-relevant employment is unevenly distributed across levels skill categories, indicating the presence of skill shortfalls within the workforce. Evidence points to a dual demand: (1) advanced capabilities to deploy, operate, and maintain modern EE technologies, and (2) foundational, entry-level competencies to widen adoption. Given this profile, a sizable share of the workforce can move up with targeted training. Designing tailored upskilling programs for specific skill bands that are aligned to actual role requirements can materially raise worker productivity and accelerate state-level EE implementation.

In conclusion, the findings underscore the pivotal role of a skilled workforce in advancing EE product manufacturing. The significant concentration of skilled EE employment across technical roles positions EE as a strategic driver for sustainable and competitive manufacturing. Closing the gap now calls for targeted policy action through

tailored skilling programs, an increased role of industries, and stronger skilling delivery, which will facilitate capabilities to spread beyond current hubs and accelerate wider EE adoption across India's manufacturing base.

Looking forward, future research in the EE domain could focus on exploring the employment and investment dynamics of

industrial EE to generate robust, policy-relevant evidence to support the design of EE measures that deliver both climate and economic dividends. In particular, estimating sectoral employment-investment multipliers, or employment coefficients indicating employment created per unit of investment, could be explored.

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Annexure

Annexure I

NIC	Description	EEG Group
101	Processing and preserving of meat	Food Processing
102	Processing and preserving of fish, crustaceans and molluscs	Food Processing
103	Processing and preserving of fruit and vegetables	Food Processing
107	Manufacture of other food products	Food Processing
131	Spinning, weaving and finishing of textiles	Textile
139	Manufacture of other textiles	Textile
151	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness; dressing and dyeing of fur	Leather
152	Manufacture of footwear	Leather
161	Sawmilling and planing of wood	Wood
162	Manufacture of products of wood, cork, straw and plaiting materials	Wood
170	Manufacture of paper and paper products	Pulp & Paper
192	Manufacture of refined petroleum products	Petroleum Refinery
201	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms	Chemicals
202	Manufacture of other chemical products	Chemicals
203	Manufacture of man-made fibres	Chemicals
210	Manufacture of pharmaceuticals, medicinal chemical and botanical products	Pharmaceutical
221	Manufacture of rubber products	Rubber & Plastic
222	Manufacture of plastics products	Rubber & Plastic
231	Manufacture of glass and glass products	Construction Materials
239	Manufacture of non-metallic mineral products n.e.c.	Construction Materials
251	Manufacture of structural metal products, tanks, reservoirs and steam generators	Construction Materials
241	Manufacture of basic iron and steel	Iron & Steel
243	Casting of metals	Iron & Steel
242	Manufacture of basic precious and other non-ferrous metals	Metal Products
259	Manufacture of other fabricated metal products; metalworking service activities	Metal Products
261	Manufacture of electronic components and boards	Electricals and electronics
262	Manufacture of computers and peripheral equipment	Electricals and electronics
263	Manufacture of communication equipment	Electricals and electronics
264	Manufacture of consumer electronics	Electricals and electronics
265	Manufacture of measuring, testing, navigating and control equipment; watches and clocks	Electricals and electronics
266	Manufacture of irradiation, electromedical and electrotherapeutic equipment	Electricals and electronics
271	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	Electricals and electronics
272	Manufacture of batteries and accumulators	Electricals and electronics
273	Manufacture of wiring and wiring devices	Electricals and electronics
274	Manufacture of electric lighting equipment	Electricals and electronics
275	Manufacture of domestic appliances	Electricals and electronics

279	Manufacture of other electrical equipment	Electricals and electronics
281	Manufacture of general-purpose machinery	Machinery and equipment
282	Manufacture of special-purpose machinery	Machinery and equipment
332	Installation of industrial machinery and equipment	Machinery and equipment
291	Manufacture of motor vehicles	Transport
293	Manufacture of parts and accessories for motor vehicles	Transport
301	Building of ships and boats	Transport
309	Manufacture of transport equipment n.e.c.	Transport
302	Manufacture of railway locomotives and rolling stock	Railways
331	Repair of fabricated metal products, machinery and equipment	Repair and Maintenance

Source: Authors' construction

Annexure II

Example for EETI calculation

Consider the case of the occupation *Energy Engineers (except wind and solar)* and its associated tasks listed in Table A1 below. Tasks that have been considered as EE-relevant have been highlighted in green, while those not included are highlighted in red.

A1: Task-based assessment for Energy Engineers (except wind and solar)

S. No.	Task	EE-Relevance	Reasoning/Keyword
1	Identify and recommend energy savings strategies to achieve more energy-efficient operation.		Related to energy-saving strategies for improving EE
2	Conduct energy audits to evaluate energy use and to identify conservation and cost reduction measures.		Targeted at energy conservation
3	Monitor and analyze energy consumption .		Targeted at energy conservation
4	Monitor energy-related design or construction issues, such as energy engineering, energy management , or sustainable design.		Energy management refers to energy adjustment and optimization via procedures and systems that lower energy requirements for each unit of output. The objective is to minimize cost and environmental impact without hampering production or quality (BEE, 2015).
5	Inspect or monitor energy systems, including heating, ventilating, and air conditioning (HVAC) or daylighting systems to determine energy use or potential energy savings .		Related to energy-saving strategies for improving EE.
6	Advise clients or colleagues on topics such as climate control systems, energy modelling, data logging, sustainable design , or energy auditing .		Forms a sub-component of energy management. The Energy Conservation Act of 2001 defines energy audits as the process of verifying, monitoring, and analysing energy use along with submitting recommendations for EE improvements, conducting cost-benefit analysis and developing action plans to curtail energy consumption (BEE, 2015).
7	Analyze, interpret, or create graphical representations of energy data, using engineering software.		Targeted at energy conservation
8	Verify energy bills and meter readings.		Targeted at energy conservation
9	Collect data for energy conservation analyses, using job site observation, field inspections, or sub-metering.		Targeted at energy conservation.
10	Manage the development, design, or construction of energy conservation projects to ensure the acceptability of budgets and timelines, conformance to federal and state laws, or adherence to approved specifications.		Targeted at energy conservation.
11	Perform energy modelling, measurement, verification, commissioning, or retro-commissioning .		Retro-commissioning involves addressing issues that may have arisen over the span of a building's life for instance those caused by

			aging equipment. It forms a sub-component of operations and maintenance of buildings and entails the identification of inefficiently operating equipment by an energy specialist. ¹⁹²⁰
12	Review architectural, mechanical, or electrical plans or specifications to evaluate energy efficiency .		Targeted at EE improvements
13	Prepare energy-related project reports or related documentation.		Not related to EE outcomes
14	Review or negotiate energy purchase agreements.		Not related to EE outcomes
15	Train personnel or clients on topics such as energy management .		Energy management refers to energy adjustment and optimization via procedures and systems that lower energy requirements for each unit of output. The objective is to minimize cost and environmental impact without hampering production or quality (BEE, 2015).
16	Direct the implementation of energy management projects.		Energy management refers to energy adjustment and optimization via procedures and systems that lower energy requirements for each unit of output. The objective is to minimize cost and environmental impact without hampering production or quality (BEE, 2015).
17	Research renewable or alternative energy systems or technologies, such as solar thermal or photovoltaic energy.		Pertains to RE and is not related to EE outcomes
18	Promote awareness or use of alternative or RE sources.		Pertains to RE and is not related to EE outcomes
19	Write or install energy management routines for building automation systems.		Energy management refers to energy adjustment and optimization via procedures and systems that lower energy requirements for each unit of output. The objective is to minimize cost and environmental impact without hampering production or quality (BEE, 2015).
20	Recommend the best fuel for specific sites or circumstances.		Involves the identification of fuels to ensure energy-efficient conversion (BEE, 2015).
21	Consult with construction or renovation clients or other engineers on topics such as Leadership in Energy and Environmental Design (LEED) or Green Buildings.		Pertains to EE and green buildings.

Source: Authors' construction using task description as provided in O*NET Database

Using the formula presented in Section 4.2 (B), the EETI index for the occupation *Energy Engineers (except wind and solar)* would be:

$$EETI_{Energy\ Engineers, Except\ Wind\ and\ Solar} = \frac{17}{21} * 100 = 80.95$$

¹⁹ Available at: <https://www.inversenergy.com/Home/CommissioningRetro>. Accessed on 10 April, 2025.

²⁰ Available at: <https://www.ashrae.org/technical-resources/ashrae-journal/featured-articles/persistence-in-energy-savings-from-retro-commissioning-measures>. Accessed on 10 April, 2025

Annexure III

Energy Auditor²¹

S.No.	Task_O*NET	Task_NCO
Mapped		
1	Identify and prioritize energy-saving measures.	Inspects homes of utility company customers to identify conditions that cause energy waste and suggests actions to reduce waste. Reads geyser to ascertain tank heat-loss rating and determine need for tank insulation blanket.
2	Prepare audit reports containing energy analysis results or recommendations for energy cost savings.	Calculates area of windows and house volume, using calculator, and records results on computer input form to provide data for computer calculation of heat-loss estimates that are sent to customer.
3	Identify opportunities to improve the operation, maintenance, or energy efficiency of building or process systems.	Inspects homes of utility company customers to identify conditions that cause energy waste and suggests actions to reduce waste.
4	Inspect or evaluate building envelopes, mechanical systems, electrical systems, or process systems to determine the energy consumption of each system.	Draws sketch of house, measures house perimeter, windows, and doors, using tape measure, and records dimensions on sketch for use in heat-loss calculations. Inspects areas of house, such as attics, crawl spaces, and basements, and notes conditions that contribute to energy waste, such as loose-fitting windows, uninsulated pipes, and deficient insulation. Reads geyser to ascertain tank heat-loss rating and determine need for tank insulation blanket.
5	Recommend energy-efficient technologies or alternate energy sources.	Confers with customer and recommends action to be taken to reduce energy waste, such as weather-stripping, reducing hot water temperature setting, and adding insulation.
6	Collect and analyze field data related to energy usage.	Interviews customer to obtain data relating to household energy use, such as type of heating system, number of persons at home during day and prior heating costs.
7	Educate customers on energy efficiency or answer questions on topics such as the costs of running household appliances or the selection of energy-efficient appliances.	Gives customer pamphlets describing energy conservation improvements. Confers with customer and recommends action to be taken to reduce energy waste, such as weather-stripping, reducing hot water temperature setting, and adding insulation.
8	Analyze energy bills, including utility rates or tariffs, to gather historical energy usage data.	Interviews customer to obtain data relating to household energy use, such as type of heating system, number of persons at home during day and prior heating costs.
9	Calculate potential for energy savings .	Inspects homes of utility company customers to identify conditions that cause energy waste and suggests actions to reduce waste.
10	Perform tests such as blower-door tests to locate air leaks.	Inspects homes of utility company customers to identify conditions that cause energy waste and suggests actions to reduce waste.

²¹ 8 tasks as per National Classification of Occupations (2015) Vol II – A

11	Measure energy usage with devices such as data loggers, universal data recorders, light meters, sling psychrometers, psychrometric charts, flue gas analyzers, amp probes, watt meters, volt meters, thermometers, or utility meters.	Inspects homes of utility company customers to identify conditions that cause energy waste and suggests actions to reduce waste.
Not mapped		
12	Identify any health or safety issues related to planned weatherization projects.	
13	Analyze technical feasibility of energy-saving measures , using knowledge of engineering, energy production, energy use, construction, maintenance, system operation, or process systems.	
14	Examine commercial sites to determine the feasibility of installing equipment that allows building management systems to reduce electricity consumption during peak demand periods .	
15	Prepare job specification sheets for home energy improvements, such as attic insulation, window retrofits, or heating system upgrades.	
16	Inspect newly installed energy-efficient equipment to ensure that it was installed properly and is performing according to specifications.	
17	Quantify energy consumption to establish baselines for energy use or need.	
18	Determine patterns of building use to show annual or monthly needs for heating, cooling, lighting, or other energy needs.	
19	Compare existing energy consumption levels to normative data.	
20	Oversee installation of equipment such as water heater wraps, pipe insulation, weatherstripping, door sweeps, or low-flow showerheads to improve energy efficiency .	
21	Verify income eligibility of participants in publicly financed weatherization programs.	

Heating, Air Conditioning, and Refrigeration Mechanics and Installers²²

S.No.	Task_O*NET	Task_NCO
Mapped		
1	Connect heating or air conditioning equipment to fuel, water, or refrigerant source to form complete circuit.	Connects heating and air-conditioning equipment to facilities, such as heating unit, water lines and spray devices, to set up control temperatures and moisture conditions.
2	Inspect and test systems to verify system compliance with plans and specifications or to detect and locate malfunctions.	Tests efficiency of heating and air-conditioning equipment under stimulated operating conditions
		Couples gauges and instruments to system and starts equipment. Observes and records readings of instruments such as thermometers, thermocouples, air flow meters, voltmeters ammeters, and pressure and draft gauges.
3	Install, connect, or adjust thermostats, humidistats, or timers.	Connects heating and air-conditioning equipment to facilities, such as heating unit, water lines and spray devices, to set up control temperatures and moisture conditions.
4	Test electrical circuits or components for continuity, using electrical test equipment.	Couples gauges and instruments to system and starts equipment. Observes and records readings of instruments such as thermometers, thermocouples, air flow meters, voltmeters ammeters, and pressure and draft gauges.
5	Install auxiliary components to heating or cooling equipment, such as expansion or discharge valves, air ducts, pipes, blowers, dampers, flues, or stokers.	Constructs cardboard air ducts and other accessories for use in testing equipment
6	Record and report time, materials, faults, deficiencies, or other unusual occurrences on work orders.	Informs supervisor of unusual noise and instrument readings during operation of equipment. May plot recorded data.
7	Keep records of repairs and replacements made and causes of malfunctions.	Informs supervisor of unusual noise and instrument readings during operation of equipment. May plot recorded data.
8	Test pipes, lines, components, and connections for leaks.	Tests efficiency of heating and air-conditioning equipment under stimulated operating conditions
9	Study blueprints, design specifications, or manufacturers' recommendations to ascertain the configuration of heating or cooling equipment components and to ensure the proper installation of components.	Connects heating and air-conditioning equipment to facilities, such as heating unit, water lines and spray devices, to set up control temperatures and moisture conditions.
Not Mapped		
10	Comply with all applicable standards, policies, or procedures, such as safety procedures or the maintenance of a clean work area.	
11	Discuss heating or cooling system malfunctions with users to isolate problems or to verify that repairs corrected malfunctions.	
12	Adjust system controls to settings recommended by manufacturer to balance system.	

²² 5 tasks as per National Classification of Occupations (2015) Vol II – A

13	Recommend, develop, or perform preventive or general maintenance procedures, such as cleaning, power-washing, or vacuuming equipment, oiling parts, or changing filters.	
14	Repair or replace defective equipment, components, or wiring.	
15	Install or repair self-contained ground source heat pumps or hybrid ground or air source heat pumps to minimize carbon-based energy consumption and reduce carbon emissions.	
16	Braze or solder parts to repair defective joints and leaks.	
17	Lay out and connect electrical wiring between controls and equipment, according to wiring diagrams, using electrician's hand tools.	
18	Perform mechanical overhauls and refrigerant reclaiming.	
19	Install expansion and control valves, using acetylene torches and wrenches.	
20	Measure, cut, thread, or bend pipe or tubing, using pipe fitter's tools.	
21	Mount compressor, condenser, and other components in specified locations on frames, using hand tools and acetylene welding equipment.	
22	Install dehumidifiers or related equipment for spaces that require cool, dry air to operate efficiently, such as computer rooms.	
23	Cut or drill holes in floors, walls, or roof to install equipment, using power saws or drills.	
24	Estimate, order, pick up, deliver, and install materials and supplies needed to maintain equipment in good working condition.	
25	Schedule work with customers and initiate work orders, house requisitions, and orders from stock.	
26	Supervise and instruct assistants.	
27	Lay out reference points for installation of structural and functional components, using measuring instruments.	
28	Lift and align components into position, using hoist or block and tackle.	
29	Install or repair air purification systems, such as specialized filters or ultraviolet (UV) light purification systems.	
30	Repair or service heating, ventilating, and air conditioning (HVAC) systems to improve efficiency, such as by changing filters, cleaning ducts, and refilling non-toxic refrigerants.	

Automotive Engineering Technicians²³

S.No.	Task_O*NET	Task_NCO
Mapped		
1	Set up mechanical, hydraulic, or electric test equipment in accordance with engineering specifications, standards, or test procedures.	Sets up and operates equipment to test automobile parts and accessories according to standard procedures to discover design and fabrication faults.
2	Read and interpret blueprints, schematics, work specifications, drawings, or charts.	Studies drawings, sketches, specifications set, and installs units such as assemblies, gears, universal joints in testing equipment and machines and connects wiring, tubing, couplings and power sources using hand tools.
3	Inspect or test parts to determine nature or cause of defects or malfunctions.	May specialize in testing or repairs of particular type of auto equipment and accessories.
4	Monitor computer-controlled test equipment, according to written or verbal instructions.	Operates test equipment and machines to determine factors such as stress, strain, pressure, flow of fuel, oil and air, wear and usability of installed units under conditions of heat, cold, high speeds and load.
5	Analyze test data for automotive systems, subsystems, or component parts.	Conducts investigations into and experimental tests in development of new automotive equipment and accessories to secure more economical operating basis and lowering manufacturing cost.
6	Install equipment, such as instrumentation, test equipment, engines, or aftermarket products, to ensure proper interfaces.	Studies drawings, sketches, specifications set, and installs units such as assemblies, gears, universal joints in testing equipment and machines and connects wiring, tubing, couplings and power sources using hand tools.
7	Perform or execute manual or automated tests of automotive system or component performance, efficiency, or durability.	Sets up and operates equipment to test automobile parts and accessories according to standard procedures to discover design and fabrication faults.
8		Operates test equipment and machines to determine factors such as stress, strain, pressure, flow of fuel, oil and air, wear and usability of installed units under conditions of heat, cold, high speeds and load.
9	Maintain test equipment in operational condition by performing routine maintenance or making minor repairs or adjustments as needed.	Supervises assembly and repair work, effects necessary modifications and replacements of parts and checks completed assembly for efficiency of performances.
10	Improve fuel efficiency by testing vehicles or components that use lighter materials, such as aluminum, magnesium alloy, or plastic.	Studies in detail costs involved and seeks lighter and stronger metal parts in auto.
11	Fabricate new or modify existing prototype components or fixtures.	Supervises assembly and repair work, effects necessary modifications and replacements of parts and checks completed assembly for efficiency of performances.
12	Recommend product or component design improvements, based on test data or observations.	Conducts investigations into and experimental tests in development of new automotive equipment and accessories to secure more economical operating basis and lowering manufacturing cost.
13	Build instrumentation or laboratory test equipment for special purposes.	May specialize in testing or repairs of particular type of auto equipment and accessories.

²³ 7 tasks as per National Classification of Occupations (2015) Vol II – A

Not Mapped		
14	Document test results, using cameras, spreadsheets, documents, or other tools.	
15	Analyze performance of vehicles or components that have been redesigned to increase fuel efficiency, such as camless or dual-clutch engines or alternative types of air-conditioning systems.	
16	Order new test equipment, supplies, or replacement parts.	
17	Recommend tests or testing conditions in accordance with designs, customer requirements, or industry standards to ensure test validity.	
18	Test performance of vehicles that use alternative fuels, such as alcohol blends, natural gas, liquefied petroleum gas, biodiesel, nano diesel, or alternative power methods, such as solar energy or hydrogen fuel cells.	
19	Participate in research or testing of computerized automotive applications, such as telemetrics, intelligent transportation systems, artificial intelligence, or automatic control.	

Power Plant Operators²⁴

S.No.	Task_O*NET	Task_NCO
Mapped		
1	Adjust controls to generate specified electrical power or to regulate the flow of power between generating stations and substations.	Adjusts transformer controls to regulate flow of power between generating stations and substations. Operates boilers, turbines, generators, and auxiliary, equipment at generating plant to produce electricity: Monitors control board and regulates equipment, according to procedures and information obtained from recording and indicating instruments. Operates switchgear to regulate and transfer power loads to protect maintenance workers engaged in repairing or cleaning equipment.
2	Monitor power plant equipment and indicators to detect evidence of operating problems.	Monitors gauges to determine effect of generator load on related equipment, such as bus bars and voltage regulators.
3	Control generator output to match the phase, frequency, or voltage of electricity supplied to panels.	Adjusts controls to regulate speed, voltage, and phase of incoming turbines to coincide with voltage and phase of power being generated.
4	Control or maintain auxiliary equipment, such as pumps, fans, compressors, condensers, feedwater heaters, filters, or chlorinators, to supply water, fuel, lubricants, air, or auxiliary power.	Controls operation of boiler auxiliary equipment, such as water and vacuum pumps, coal driers and pulverisers, steam condensers, and soot blowers, to ensure efficient operation of boilers.
5	Control power generating equipment, including boilers, turbines, generators, or reactors, using control boards or semi-automatic equipment.	Operates boilers, turbines, generators, and auxiliary, equipment at generating plant to produce electricity: Monitors control board and regulates equipment, according to procedures and information obtained from recording and indicating instruments. Adjusts boiler controls to provide steam at specified temperature and pressure for turbine loads according to power demands.
6	Start or stop generators, auxiliary pumping equipment, turbines, or other power plant equipment as necessary.	Adjusts controls of water and cold feed systems, blowers, and igniters to start up or shut down boilers.
7	Open and close valves and switches in sequence to start or shut down auxiliary units.	Adjusts controls of water and cold feed systems, blowers, and igniters to start up or shut down boilers.
8	Communicate with systems operators to regulate and coordinate line voltages and transmission loads and frequencies.	Adjusts controls to regulate speed, voltage, and phase of incoming turbines to coincide with voltage and phase of power being generated. Synchronizes incoming generating units with units in operation and closes circuit breaker at exact instant of coincidence.
9	Inspect records or log book entries or communicate with plant personnel to assess equipment operating status.	Records malfunctions of equipment, instruments, or controls on log sheet.

²⁴ 10 tasks as per National Classification of Occupations (2015) Vol II – A

10	Take regulatory action, based on readings from charts, meters and gauges, at established intervals.	Monitors gauges to determine effect of generator load on related equipment, such as bus bars and voltage regulators.
11	Record and compile operational data by completing and maintaining forms, logs, or reports.	Records malfunctions of equipment, instruments, or controls on log sheet.
12	Regulate equipment operations and conditions, such as water levels, based on instrument data or from computers.	Adjusts boiler controls to provide steam at specified temperature and pressure for turbine loads according to power demands.
Not mapped		
13	Clean, lubricate, or maintain equipment, such as generators, turbines, pumps, or compressors, to prevent failure or deterioration.	
14	Place standby emergency electrical generators on line in emergencies and monitor the temperature, output, and lubrication of the system.	
15	Make adjustments or minor repairs, such as tightening leaking gland or pipe joints.	
16	Operate, control, or monitor equipment, such as acid or gas carbon dioxide removal units, carbon dioxide compressors, or pipelines, to capture, store, or transport carbon dioxide exhaust.	
17	Operate, control, or monitor gasifiers or related equipment, such as coolers, water quenches, water gas shifts reactors, or sulfur recovery units, to produce syngas or electricity from coal.	
18	Operate, control, or monitor integrated gasification combined cycle (IGCC) or related equipment, such as air separation units, to generate electricity from coal.	
19	Operate or maintain distributed power generation equipment, including fuel cells or microturbines, to produce energy on-site for manufacturing or other commercial purposes.	
20	Examine and test electrical power distribution machinery and equipment, using testing devices.	
21	Receive outage calls and request necessary personnel during power outages or emergencies.	
22	Collect oil, water, or electrolyte samples for laboratory analysis.	
23	Analyze the layout, instrumentation, or function of electrical generation or transmission facilities.	
24	Diagnose or troubleshoot problems with gas collection systems.	
25	Monitor well fields periodically to ensure proper functioning and performance.	
26	Operate landfill gas, methane, or natural gas-fueled electrical generation systems.	
27	Prepare and submit compliance, operational, and safety forms or reports.	
28	Repair or replace gas piping.	
29	Trace electrical circuitry to ensure compliance of electrical systems with applicable codes or laws.	
30	Verify that well field monitoring data conforms to applicable regulations.	

Nuclear Engineers²⁵

S.No.	Task_O*NET	Task_NCO
Mapped		
1	Monitor nuclear facility operations to identify any design, construction, or operation practices that violate safety regulations and laws or could jeopardize safe operations.	Monitors nuclear tests and examines operations of facilities which process or utilize radioactive or fissionable material to ensure efficient functioning and conformance with safety specifications, regulations, and laws.
2	Design or develop nuclear equipment, such as reactor cores, radiation shielding, or associated instrumentation or control mechanisms.	Designs and develops nuclear equipment and monitors testing, operation, and maintenance of nuclear reactors. Plans and conducts nuclear research to discover facts or to test, prove, or modify known nuclear theories concerning release, control, and utilisation of nuclear energy.
3	Direct operating or maintenance activities of nuclear power plants to ensure efficiency and conformity to safety standards.	May direct operating and maintenance activities of operational nuclear facilities.
4	Recommend preventive measures to be taken in the handling of nuclear technology, based on data obtained from operations monitoring or from evaluation of test results.	Studies nuclear fuel cycle to define most economical uses of nuclear material and safest means of waste products disposal.
5	Prepare technical reports of findings or recommendations, based on synthesized analyses of test results.	Prepares technical reports, utilising knowledge obtained during research and development activities and inspectional functions.
6	Conduct tests of nuclear fuel behavior and cycles or performance of nuclear machinery and equipment to optimize performance of existing plants.	Monitors nuclear tests and examines operations of facilities which process or utilize radioactive or fissionable material to ensure efficient functioning and conformance with safety specifications, regulations, and laws.
7	Design or oversee construction or operation of nuclear reactors, power plants, or nuclear fuels reprocessing and reclamation systems.	Plans, designs, and develops nuclear equipment such as reactor cores, radiation shielding, and associated instrumentation and control mechanisms.
8	Design or direct nuclear research projects to develop, test, modify, or discover new uses for theoretical models.	Nuclear Engineer conducts research into problems of nuclear energy systems.
9	Design fuel cycle models or processes to reduce the quantity of radioactive waste generated from nuclear activities.	Studies nuclear fuel cycle to define most economical uses of nuclear material and safest means of waste products disposal.
10	Consult with other scientists to determine parameters of experimentation or suitability of analytical models.	Nuclear Engineer conducts research into problems of nuclear energy systems. Evaluates findings to develop new concepts of thermonuclear analysis and new uses of radioactive processes.
11	Perform experiments that will provide information about acceptable methods of nuclear material usage, nuclear fuel reclamation, or waste disposal.	Plans and conducts nuclear research to discover facts or to test, prove, or modify known nuclear theories concerning release, control, and utilisation of nuclear energy.

²⁵ 9 tasks as per National Classification of Occupations (2015) Vol II – A

Not mapped		
12	Discuss construction project proposals with interested parties, such as vendors, contractors, or nuclear facility review boards.	
13	Keep abreast of developments and changes in the nuclear field by reading technical journals or by independent study and research.	
14	Initiate corrective actions or order plant shutdowns in emergency situations.	
15	Examine accidents to obtain data for use in design of preventive measures.	
16	Write operational instructions to be used in nuclear plant operation or nuclear fuel or waste handling and disposal.	
17	Conduct environmental studies on topics such as nuclear power generation, nuclear waste disposal, or nuclear weapon deployment.	
18	Direct environmental compliance activities associated with nuclear plant operations or maintenance.	
19	Prepare environmental impact statements, reports, or presentations for regulatory or other agencies.	
20	Develop or contribute to the development of plans to remediate or restore environments affected by nuclear radiation, such as waste disposal sites.	

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