MACROECONOMIC IMPACTS OF COAL PHASE DOWN IN INDIA

An Empirical Investigation and Exploration – A Scoping Study

Abstract

This scoping study brings out the nuanced layers of possible impacts and effects of probable phase down of coal mines in India. The study seeks to highlight, through its macroeconomic model, when the coal phase down may happen, based on a detailed characterization of coal and thermal power sector, drawing on secondary data. Further, the study highlights, what are the sector specific welfare impacts of such a phase down for the Indian Economy.

As the coal economy assets would be repurposed, there will be a need to strategize on action required for reskilling and absorbing the labor in these new assets to avoid acute informalization of labor and to maintain the household economy.
By investigating and exploring these impacts, the study for the first time opens out the hidden contexts of labor informalization that can arise in the coal sector in future, as India phases down coal production and moves to a net zero pathway by 2070. The study concludes with the action points for the way forward for a balanced transition. These action areas would also contribute towards policy recommendations and frameworks that need to be designed, to address the imminent labor informalization in the coal sector, in the backdrop of future coal phase down in India. The sections below are *Phase I* of this Scoping Study. This study will lead to actionable projects that address various aspects of coal phase down.

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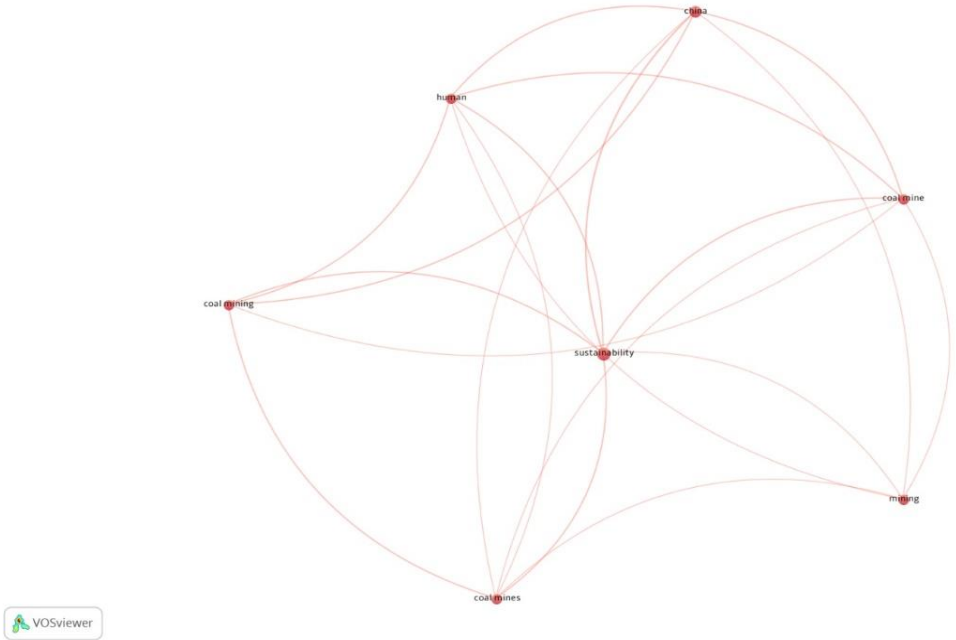
1. Introduction:

In 2023-24, **997.826** MT (Million Tonnes) of raw coal was mined in India. A total of 909.005 MT of non-coking coal was despatched. Out of this 859.336 MT went to power sector (utilities and captive)[1]. Power Sector remains the major consumer of coal and driver of coal demand. Hence any major change in this sector will have a huge effect on coal demand and mining.

In India, electricity is produced from both conventional sources, such as thermal, nuclear, and hydro-electric (hydel), as well as renewable sources like wind, solar, and biomass. However, coal-based thermal power plants contribute the largest share, accounting for approximately 75% of total electricity generation. The electricity generation target for the year 2023-24 was fixed at 1750 BU comprising of 1324.110 BU of Thermal alone[2]. As per NEP (National Electricity Plan) 2022-32, the projection for electricity demand is likely to be 1907.8 BU for the year 2026-27 and 2473.7 BU for the year 2031-32. Thus, there is a steady growth projected in demand for electricity in the coming decades.

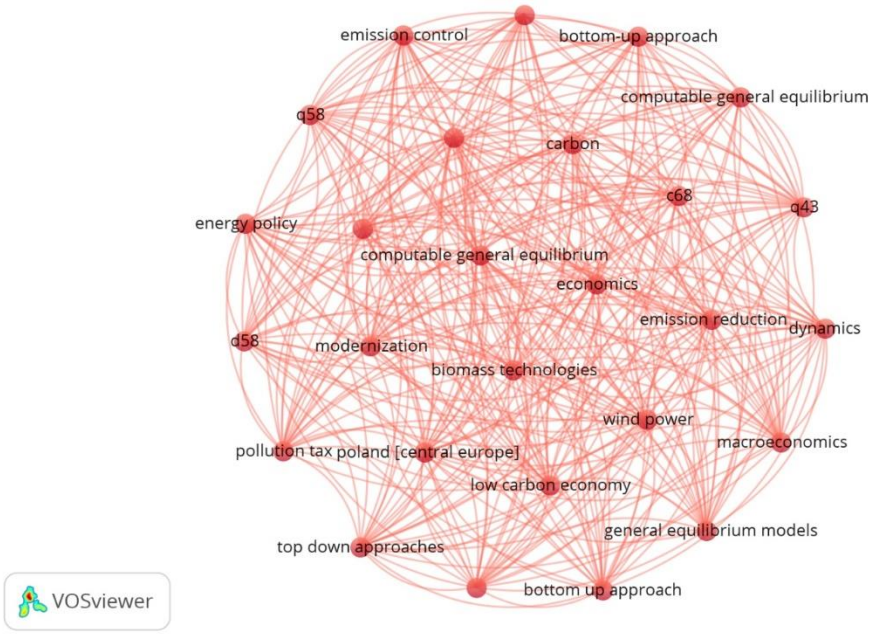
While this is the larger picture of the electricity demand situation in India, an understanding of the drivers behind the coal phase down is being attempted through a bibliometric analysis. The next section indicates some of the broad findings of the bibliometric analysis from the developed and developing country literature, where coal phase down is being attempted or initiated –

2. Bibliographic Analysis:



[1] Coal Directory of India (2023-2024)

[2] Ministry of power, Power Sector at a Glance ALL INDIA (2023)



From the bibliometric analysis of the literature, it emerges that, macroeconomic studies dealing with coal phase down, have mostly adopted a computable general equilibrium approach, for explaining the impacts of coal phase down on the economy. The global and local literature also highlight, that the basic essence of coal phase down is driven by the need to move towards the path of decarbonisation, carbon emission reduction and low carbon economy priorities.

The global literature also indicates the primacy of new low carbon energy policies, in measures to address decarbonisation, leading to the discussion on coal phase down. The alternatives being discussed as a substitute for coal, in the path of decarbonisation measures, are largely – wind, solar and biomass technologies. The bibliometric analysis using network effects clearly reflects this pattern. The literature also indicates that the path and decision of coal phase down is being determined by pollution control policies, energy policies and the larger macroeconomic considerations of a coal phase down. Within the literature discourse from the developed countries, it emerges that often the decision of coal phase down is also being determined by the core agenda of economic, environmental, governance domains of sustainability which drives the centrality and core agenda of coal phase down as a part of people centric energy transition measures all across the world.

3. Background:

Coal is a dominant source of employment and revenues for states of Odisha, Chhattisgarh, Jharkhand and Madhya Pradesh, going by predominance of source of raw coal. Besides these states, coal is also mined in West Bengal, Assam and Maharashtra. Nearly 28 Public Sector and 18 Pvt sector companies are involved in mining across these states. In 2023-24, production of Coal touched 997.8 million tonnes. Out of 973 MT despatch of raw coal, as much as 859.336 MT went to power sector. This reflects on the close relation between the Coal Mining Industry and Electricity Generation. Thus, understanding trends of Thermal based power generation are critical to assess the phasedown of coal in India's economy and its concomitant impact on all related stakeholders.

India's energy transition is gaining momentum, with renewable energy capacity expanding rapidly across several states. At an all-India level, installed capacity of renewables stood at 125159.805 MW as on 31st March 2023-24. However, despite these advancements, the country's power sector remains heavily reliant on thermal power, particularly coal-based generation, to meet its growing energy demand. While solar and wind are making significant contributions, their intermittent nature and lack of large-scale battery storage solutions prevent them from fully replacing traditional power sources like thermal power.

When analysing the installed capacity mix across states, it is evident that several states have made significant investments in renewable energy infrastructure. These investments highlight the growing commitment to transitioning to cleaner sources of power. Upcoming Central Government and State Government policies are further reinforcing this trend, as they reflect ambitious plans to expand renewable energy generation capacity. These policies not only signal a shift towards sustainable energy solutions but also emphasize the strategic importance of renewables in ensuring long-term energy security and meeting emission reduction targets.

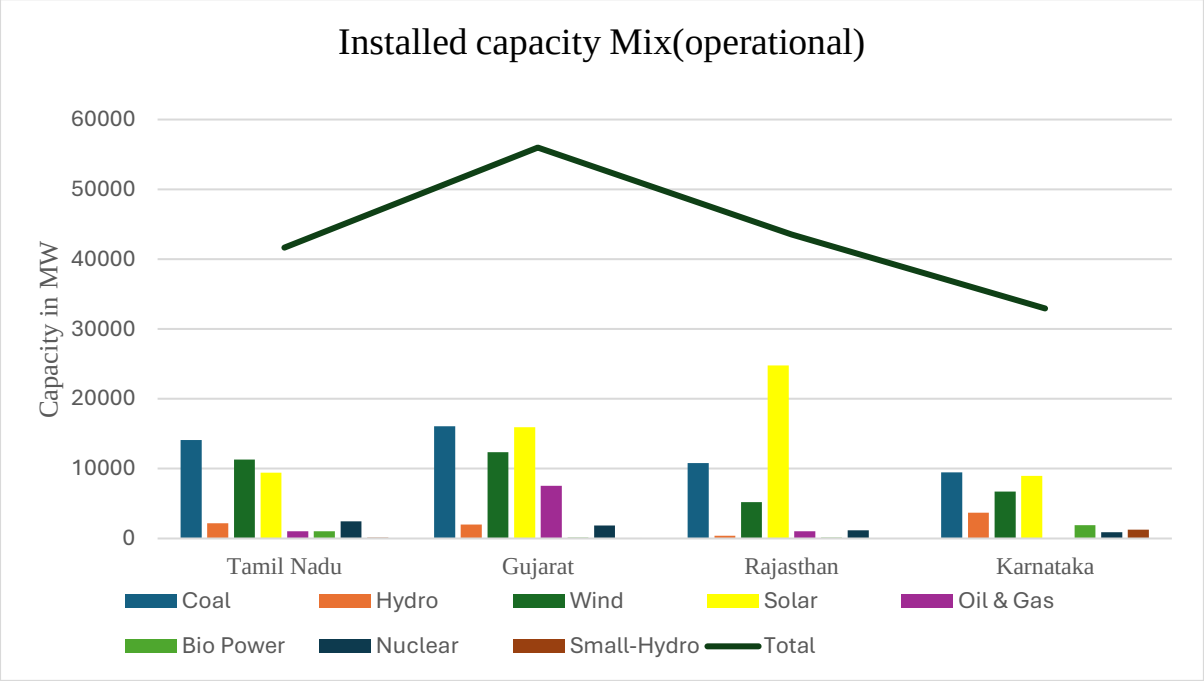


Figure 1 Installed capacity mix of operational plants[3]

Tamil Nadu, Gujarat, Rajasthan, and Karnataka are leading states in renewable energy adoption, with numerous projects in the pipeline and significant investments in renewable energy infrastructure (refer figure 1 above). At a first glance, the installed capacity mix of these states suggest that renewables are competitive with conventional energy sources, making a large-scale coal phase-out seem feasible. However, a closer look at the actual energy generation mix tells a different story, as reflected in the data below.

[3] CEA General Review 2024

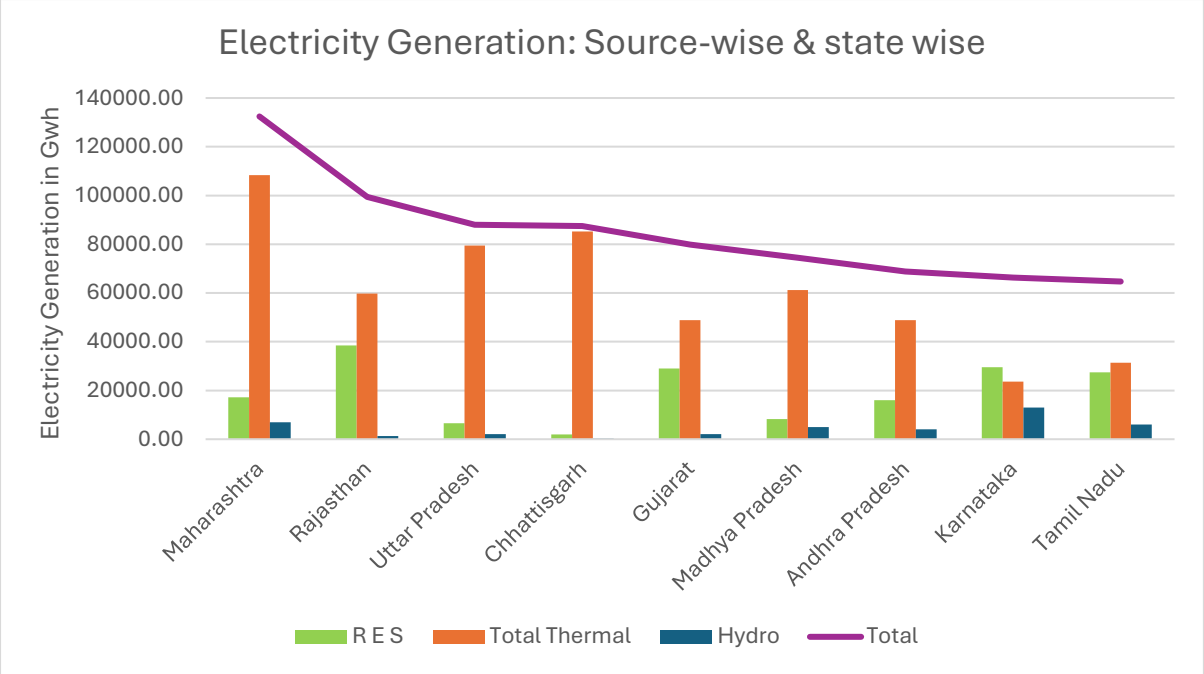


Figure 2 Energy generation mix

Although states like Gujarat and Rajasthan have a significant share of installed renewable capacity, this does not necessarily translate into proportionate energy generation. The power sector, particularly electricity generation, remains heavily reliant on coal-based power. While nuclear energy has no presence in the generation mix and hydropower holds only a small share, solar and wind contribute significantly to installed capacity. However, the effective generation output is still far from matching thermal power generation. Even if the installed capacity is to completely translate to power generation, the PLF (Plant Load Factor) of a solar plant is much lower than the PLF of the thermal plant of equivalent capacity.

An added dimension is dependence on imports from grid, even in those states where there is significant installed capacity of RES (Renewable Energy Sources). This alone gives the complete picture on coal dependence. For example, installed capacity of solar is high in Rajasthan. However, import from grid is also significant. In 2022-23, Rajasthan imported a total of 32117.62 GWh from the grid.

A deeper analysis of the thermal power sector highlights that coal-based generation overwhelmingly dominates the energy mix. In contrast, other thermal sources such as gas and diesel-based power plants contribute only a marginal share to overall electricity generation. This heavy reliance on coal-fired power plants underscores their critical role in meeting the country's growing energy demand.

Despite the rapid expansion of renewable energy sources, coal remains the backbone of electricity generation, ensuring grid stability and reliability due to its consistent and controllable power output. Given the current infrastructure, policy landscape, and energy demand projections, coal-based electricity generation is expected to continue as the dominant power source for at least the next decade, even as states push for greater renewable energy integration.

This analysis raises a crucial question: Will renewable energy truly prove a complete replacement of non-renewable sources in the power sector? While India has made substantial progress in expanding renewable energy capacity, the intermittent nature of solar and wind power, along with the lack of adequate storage

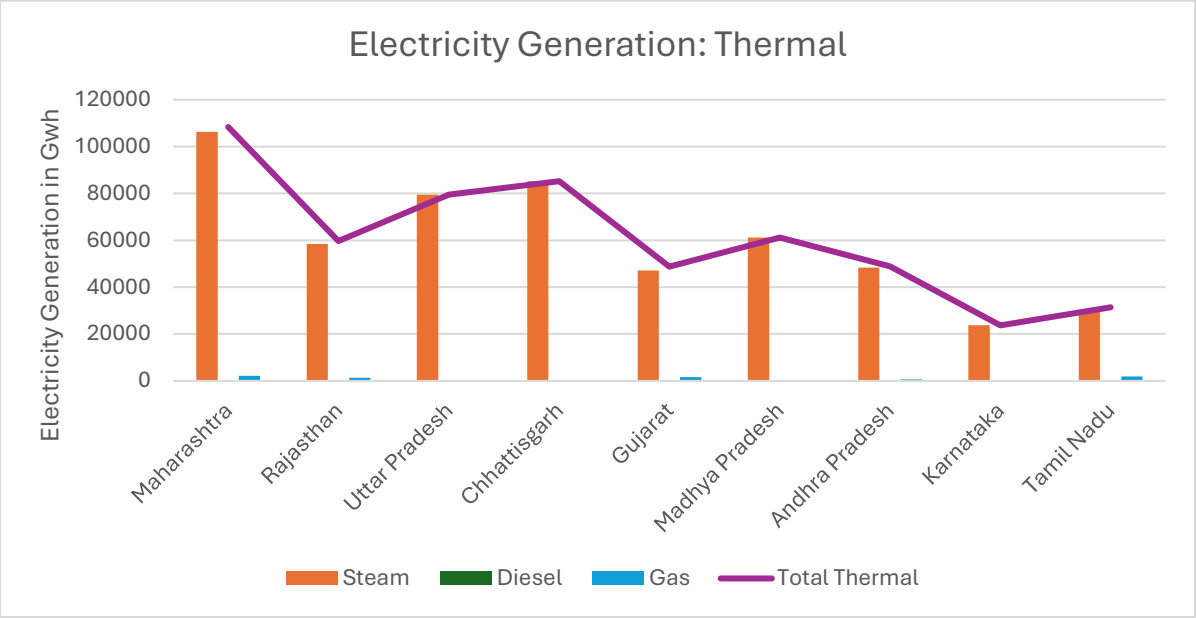


Figure 3 Electricity generation from thermal power plants for select states

solutions, poses challenges to a complete transition. Moreover, coal-fired power plants continue to provide baseload stability, making them a reliable energy source despite their environmental impact.

As India works toward its net-zero target by 2070, the question is not just about replacing coal but rather how fast and effectively the country can scale up renewables, grid infrastructure, and energy storage technologies to support a sustainable transition. Given the current trajectory, a gradual shift rather than an outright replacement of coal seems more realistic in the near future. Also, there is an evident need for a Policy Directive on ensuring concomitant battery energy storage capacity, with installed Solar, Wind and other renewables, for a balanced transition, from point of consumers, economic productivity and stability.

4. Data:

Data on coal and energy generation has been consolidated from various government bodies, including the **Central Electricity Authority (CEA), Ministry of Mines, Ministry of Power, Directorate General of Mines Safety (DGMS), and Coal Directory 2023-24 (Ministry of Coal)** among others. This analysis leverages data from multiple sources to ensure a comprehensive understanding of trends in the sector.

Historical data has been instrumental in determining growth rates across various segments. Using the **Compound Annual Growth Rate (CAGR)** and key assumptions, future projections have been made to assess potential trends. The incorporation of historical insights strengthens the analysis, making it more robust and reflective of real-world scenarios.

5. Coal Demand Projection:

Data: This exercise utilized the data from the Central Electricity Board's (CEA) annually released General Review and NITI Aayog's consolidated State-wise dataset on all power plants, including the ones in the pipeline. The last General review was published in 2024, capturing data from the years 2022-2023.

Methodology:

This was a simple projection exercise, modelled to understand the phasing out of thermal power plants assuming no new power plants will be set up other than the operational and the ones in pipeline. The following assumptions were used in the model:

1. The Life of a thermal power plant is 40 years, after which it retires,
2. If the plant has completed 40 years and is still operational in 2024, then it is assumed that it was renovated and modernized in 2015 and will remain operational till 2045.
3. 20% of TPPs will undergo renovation and modernization taking the life beyond 40 years of being operational.
4. The plants in the pipeline have a 100% probability of being set up by 2029.
5. 1 MW of installed capacity translates to 0.0055 BU.

The installed capacity of Thermal Power Plants (TPPs) is projected until **2070** using two key datasets. The first dataset is from **CEA (2024)**, which includes **596 operational TPPs**. The second dataset is from the **NITI Aayog dashboard**, listing **93 additional TPPs in the pipeline**. In total, this analysis considers **689 TPPs**.

It is important to note that TPPs are analyzed at the unit level—if a TPP has five operational units, each unit is considered separately in the projection. Additionally, only non-captive coal and lignite-based power plants are included in this study.

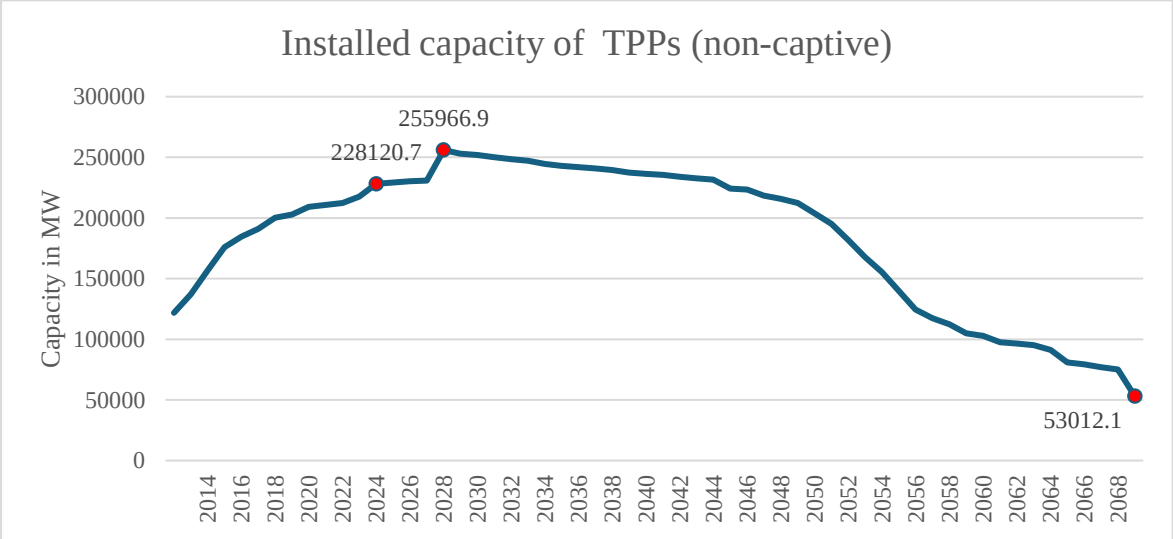


Figure 4 Installed Capacity of Thermal Power Plants

Figure 4 above, reflects the trend of installed capacity for TPPs (non-captive). This indicates that coal-based power installed capacity will peak in 2029 before gradually declining, as per assumptions above. The drop is expected to become sharper post-2046.

Based on the assumptions in paras above, and the projection of total installed capacity, the power generation from TPPs, is reflected in Fig 5 below, until 2070. Power generation from TPPs (non-captive) is peaking at 1408 BU (Billion Units) in the year 2029-30 and then declining to 1335.5 BU in 2036-37. As per latest CEA data, the demand for electricity in India is likely to be 2976.3 BU in 2036-37 with GDP growth rate being 7.3% as a business-as-usual scenario[4]. This raises a critical question: Will renewables be able to bridge the demand-supply gap as coal phases out? What will be the required pace of build-up of renewable energy sources and battery energy storage capacity?

[4] CEA data - Long Term Electricity Demand Forecasting Report, 2025

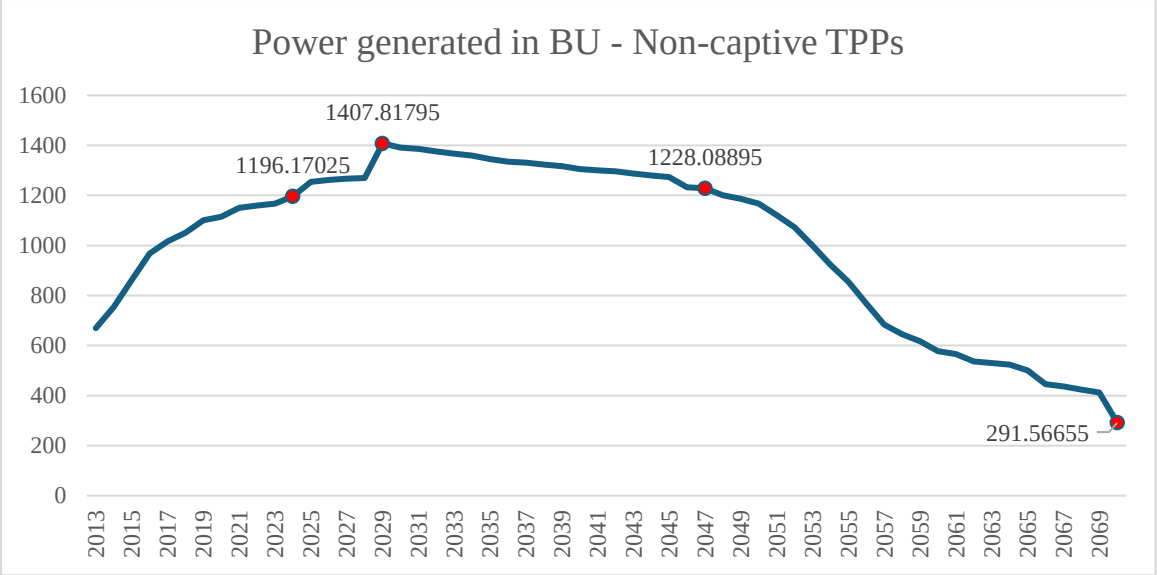


Figure 5 Year wise power generation by TPP(coal)

Market trends suggest that investors are increasingly hesitant to fund new coal exploration projects due to rising climate commitments, stringent policies, and the declining cost of renewables. With India's net-zero target for 2070, coal is becoming a less attractive investment, making way for renewable energy sources to take centre stage. However, ensuring a stable, uninterrupted power supply will require significant advancements in energy storage, grid modernization, and flexible generation technologies to support this transition. Thus, there needs to be more clarity on the future trajectory of renewable energy and alternate sources like Nuclear, along with the gestation period for commissioning before a market signal is given for complete transition away from coal.

Further, this data was utilised to calculate the coal requirement in TPPs, based on the trend of electricity generation. This ratio is calculated by considering 2024 numbers of coal despatched to non-captive-TPPs divided by total generation in given years as per our Model. According to calculation, the coal requirement is found to be 0.6655 Million tons/Billion unit of electricity generated.

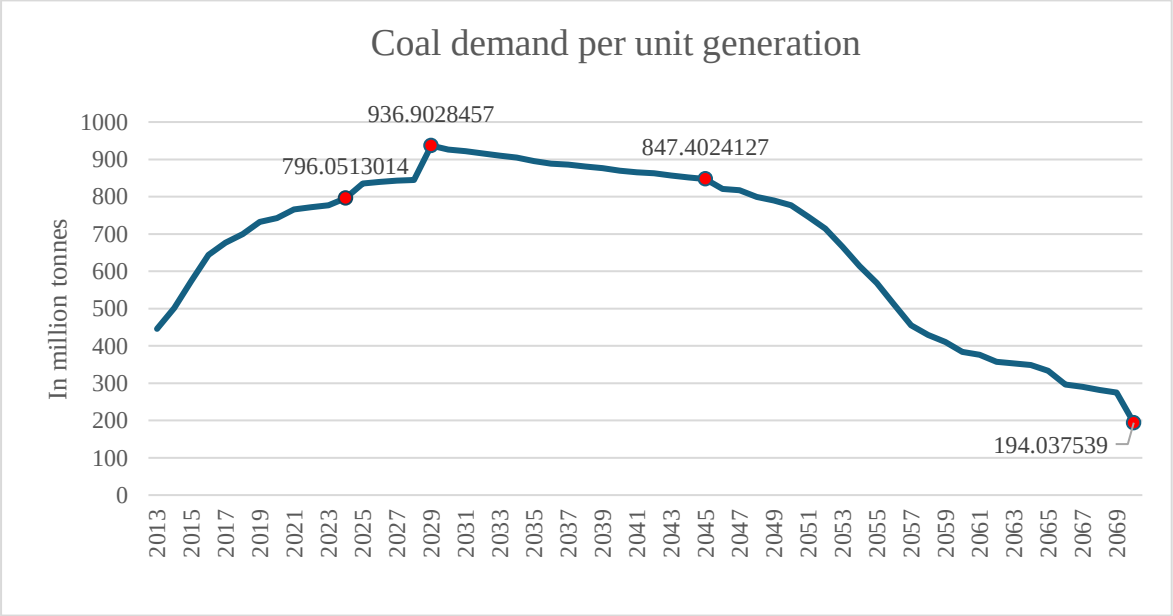


Figure 6 Yearly coal demand in TPPs (coal)

Since coal demand is directly linked to power generation, its trajectory follows a similar trend. As thermal power plants (TPPs) phase out, the demand for coal in the power sector is expected to decline significantly. According to the model, coal demand will peak in 2029 at 936.902 million tons for thermal power plants **after which it will gradually decrease, reaching 847.40 million tonnes by 2045 and then falls rapidly to 194.04 million tonnes by** 2070.

6. Model Verification

The model estimates the installed capacity of TPPs, power generation by TPPs, and coal demand for TPPs from 2013 onwards. To validate its accuracy, these estimated values are compared with actual data reported by CEA and Controller of Coal data.

- Coal demand is verified against coal dispatched to TPPs, as reported by Controller of Coal data.
- Power generation is cross-checked with actual values recorded over the years by CEA.

If the model's projections for 2013 to 2024 closely align with historical data, it provides confidence that the model can reliably forecast installed capacity, power generation, and coal demand until 2070 with reasonable accuracy. The model determines the installed capacity for a given year by summing the capacities of individual power plants. The calculated total installed capacity aligns with the officially reported figures for thermal power plants (coal and lignite) by the CEA, highlighting that the study has accounted for nearly all such plants across the country.

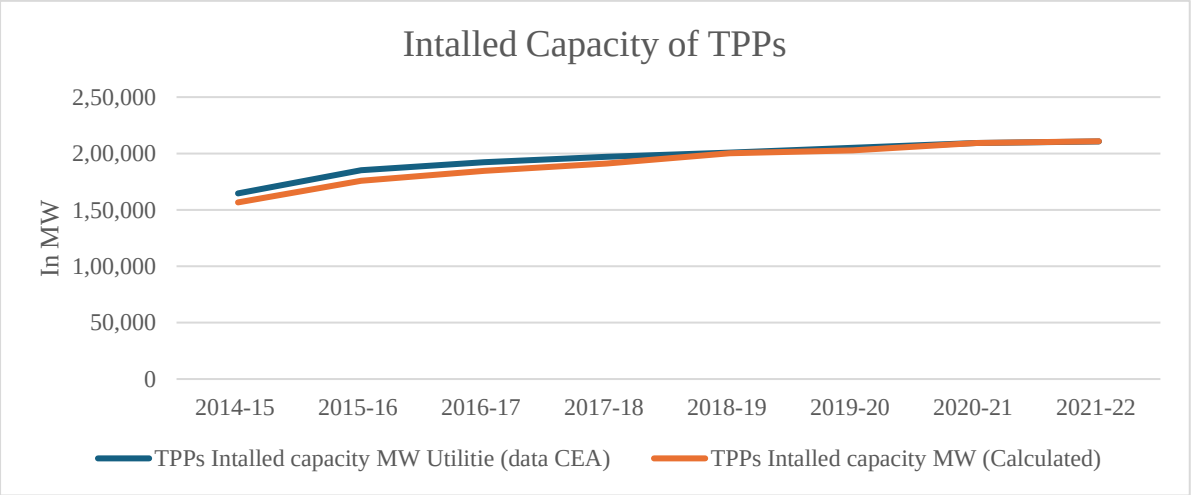


Figure 7 Comparative analysis of Installed capacity Actual Vs Model

The model estimates power generation by assuming that thermal power plants require 0.6655 million tons of coal per billion units of electricity generated. This conversion factor, derived from an analysis of historical data, is used to calculate and project coal demand for thermal power plants until 2070. The fact that the model's predicted coal demand closely aligns with historical data validates the reliability of this factor for future projections. While improvements in power plant efficiency and variations in coal's calorific value will influence coal consumption per unit of electricity over time, these factors have not been incorporated into the study for simplicity. However, they can be explored in future analyses.

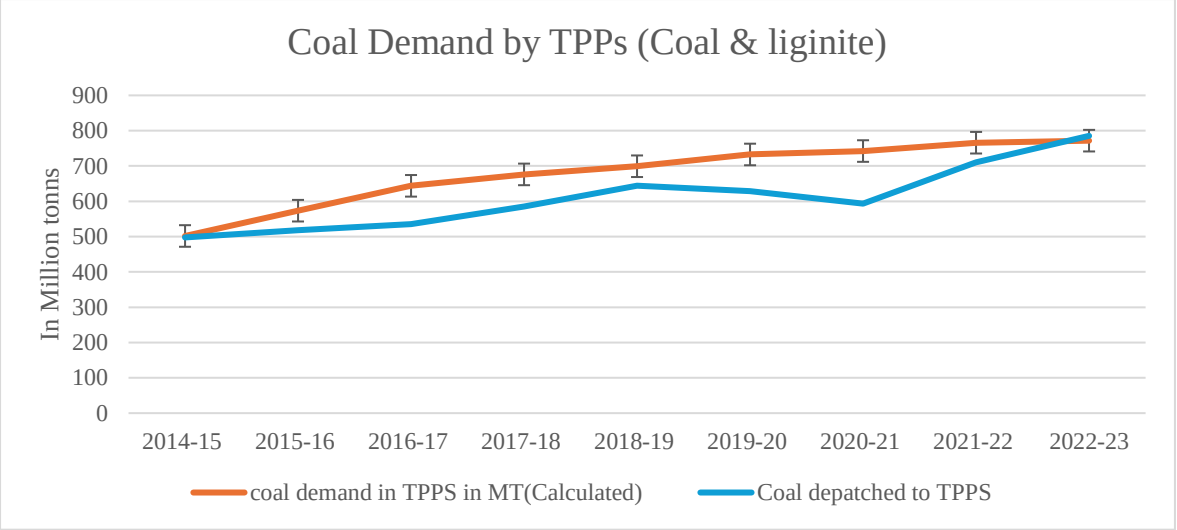


Figure 8 Comparative analysis of Coal demand by TPPs Actual Vs Model

7. Energy Demand Projections:

According to the IESS 3 model, energy consumption is expected to rise significantly in the future. This model estimates both per capita electricity demand and per capita electricity generation, using projected demand data for 2020 and 2022.CEA consumption data for 2020 and 2022 is higher than one reported by IESS.

Table 1 IESS Numbers

Years	2020	2022	2027	2030	2032	2037	2042	2047
Per Capita electricity demand (kWh)	890	927	1253	1477	1636	2083	2634	3300
Per capita generation(kWh)	951	991	1264	1470	1621	2051	2589	3246

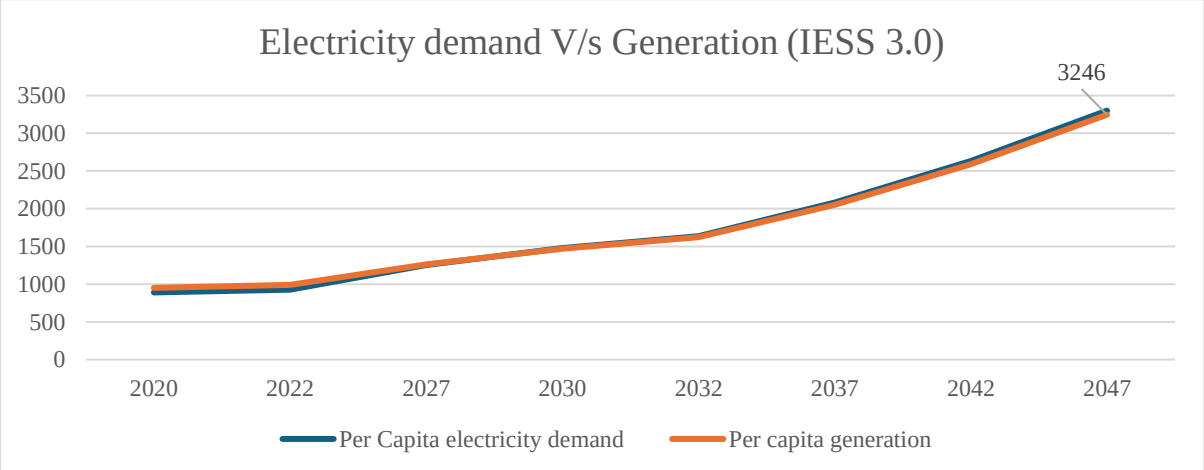


Figure 9 Per capita Electricity generation Vs Electricity demand in kWh as projected by IESS 3.0

By incorporating generation and demand figures from the Central Electricity Authority (CEA) for 2022 and extending them to 2070 using the IESS model's trajectory, a new trend emerges—**electricity consumption is projected to outpace generation**[5]. The forecasted rise in generation is higher when CEA data is used. The per capita energy consumption is expected to rise to 3704.40 KWh against 3300 KWh as projected by the IESS 3.0 model.

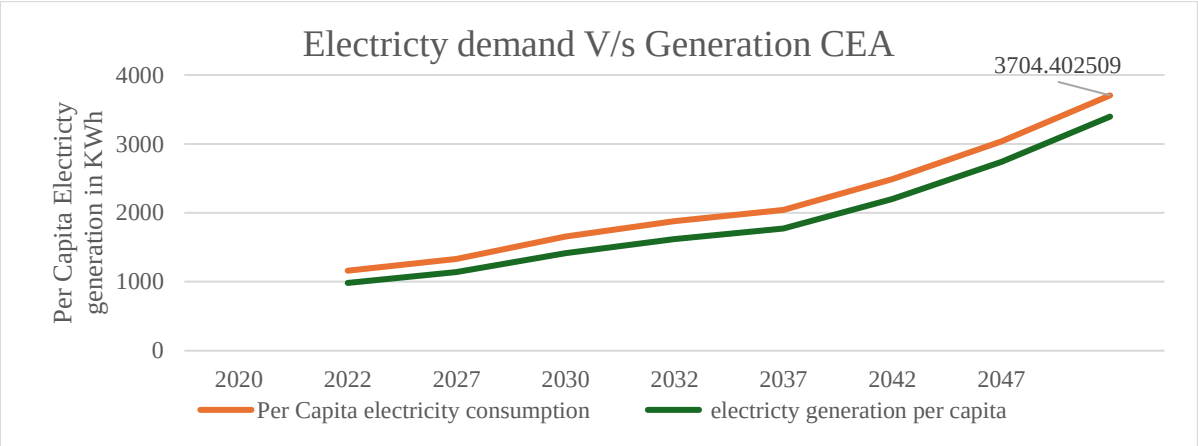


Figure 10 Per Capita electricity generation V/s consumption projection based on CEA data till 2022

By 2047, India's per capita electricity consumption is projected to reach 3,704 kWh, reflecting a 165% increase from 1,395 kWh in 2024, based on trends from IESS 3.0. Currently, India's per capita consumption remains significantly below the global average even in 2024. If India aims to align with the energy consumption levels of developed nations, a substantial rise in electricity demand is inevitable.

A critical concern arises regarding whether renewable energy infrastructure can expand rapidly enough to compensate for the decline in thermal power generation. According to projections, electricity generation from thermal power plants is expected to decline to 1,228.09 BU by 2047. Meanwhile, according to a study published in The Lancet, India's population is projected to peak around 1.6 billion by 2047, pushing total electricity demand to approximately 5,926 BU, based on projected per capita consumption.This presents a massive gap of 4698 BU that needs to be met by renewable energy and other sources. The key question remains whether renewable energy infrastructure can grow at a sufficient rate to bridge this shortfall. If not, the coal phase-down pathways will need to be rethought and recalibrated.

8. Socio-Economic effect:

The coal sector has historically been a labour-intensive industry, playing a crucial role in employment generation. Millions of workers are engaged directly in coal mining, transportation, and associated industries, while numerous indirect jobs depend on coal-driven economies. Over 69% of all coal mines are OCM and at least 25% of the total workforce is directly employed in the mines.[6]However, with the projected phase-down of coal as per the model's estimates, a significant number of workers are expected to lose their livelihoods over the coming decades. Moreover, the burden of transition is expected fall primarily on semiskilled and unskilled workers.

[5] Per capita Generation from CEA data is calculate by dividing gross electricity generated divided by total population in given year as per Work bank

[6] Coal Transition Odisha, a working paper (http://nfi.org.in/sites/nfi/files/publication/Coal%20Transition%20-%20Odisha-11-11-22%20%281%29.pdf)

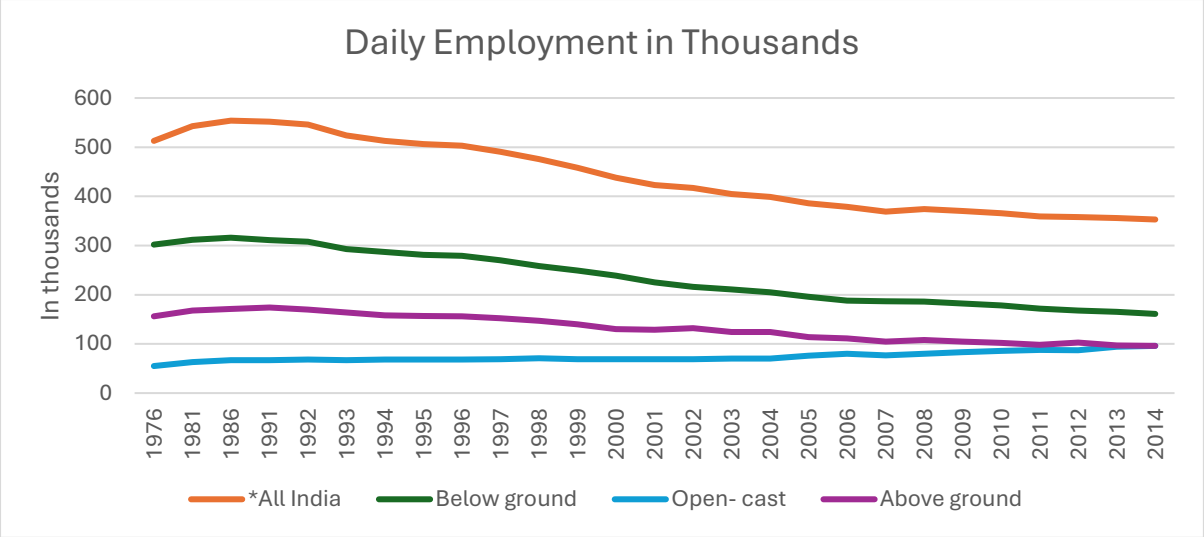


Figure 11 Historic data on daily employment in mines as reported report on Statistics Of Mines In India

While the renewable energy sector is growing rapidly and is anticipated to replace coal in meeting energy demand, it does not offer the same level of employment intensity as coal. Unlike coal mining, which requires a vast workforce for extraction, processing, and logistics, renewable energy—particularly solar and wind—relies more on technology, automation, and intermittent maintenance, leading to lower employment opportunities post-installation.

Additionally, coal-dependent regions have entire ecosystems built around mining activities, including small businesses, logistics services, truckers, industries, and informal labor markets that rely on coal workers' incomes. A direct transition from coal to renewables does not automatically absorb the displaced workforce, posing a serious challenge of structural unemployment in these areas.

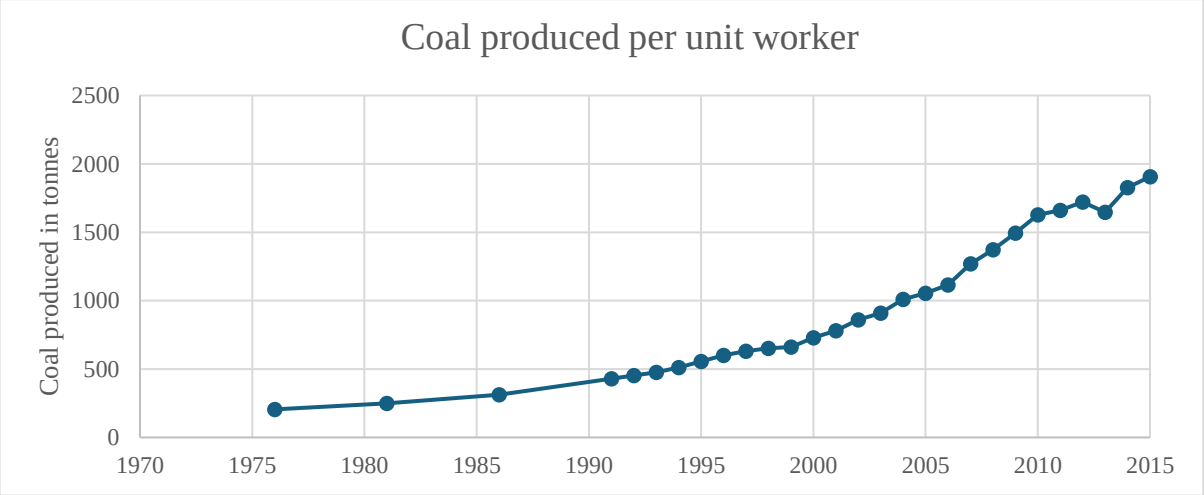


Figure 12 Coal produced per unit worker (historic data)

The above trend illustrates the employment pattern in the coal sector between 1976 and 2015, as reported in the **STATISTICS OF MINES IN INDIA VOLUME – I (COAL),2015.** [7]The data clearly indicates a steady decline in daily employment within the sector over the years. However, despite this

[7] Published by Directorate General of Mines Safety and Ministry of Labour & Employment, GoI

decline in workforce numbers, coal production has significantly increased over the same period. This suggests that the rise in output has not been driven by an increase in workforce size, but rather by adopting more advanced and efficient mining technologies.

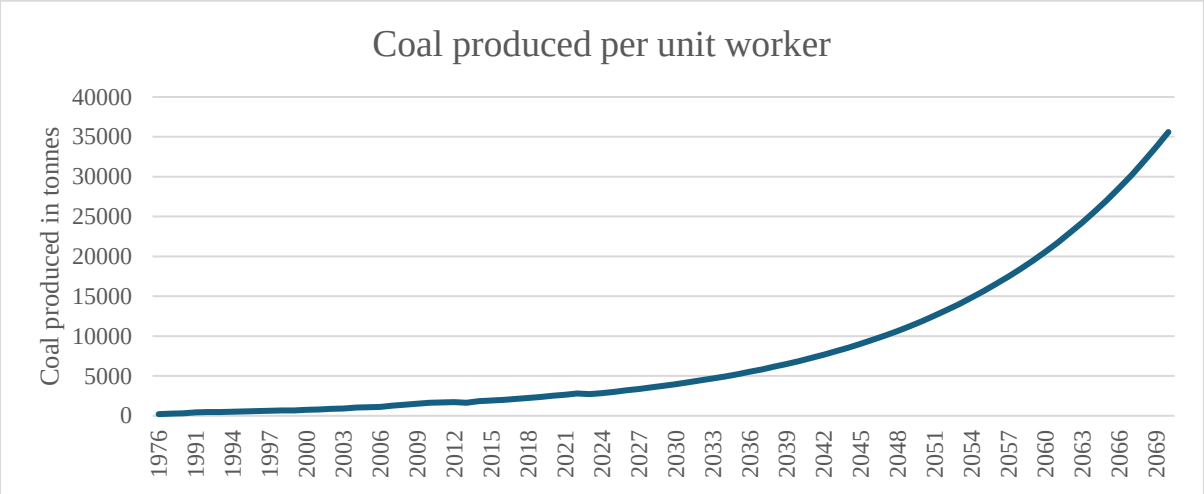


Figure 13 Coal production per unit worker projected using historic data

Given the rise in coal production alongside the decline in employment, it has been observed that output per worker in the coal sector has increased exponentially over the past 44 years. This significant rise can be attributed to the adoption of more efficient and advanced mining technologies, which have enhanced productivity while reducing labor intensity. With continued technological advancements, such as automation, AI-driven resource optimization, and mechanized mining, the output per worker is expected to further increase in the future. As mining operations become more digitized and efficient, the sector will likely continue this trend of higher productivity with a smaller workforce. This increase in productivity per worker, driven by the adoption of advanced and sophisticated technologies, clearly indicates the likelihood of further job losses in the coal sector in the future.

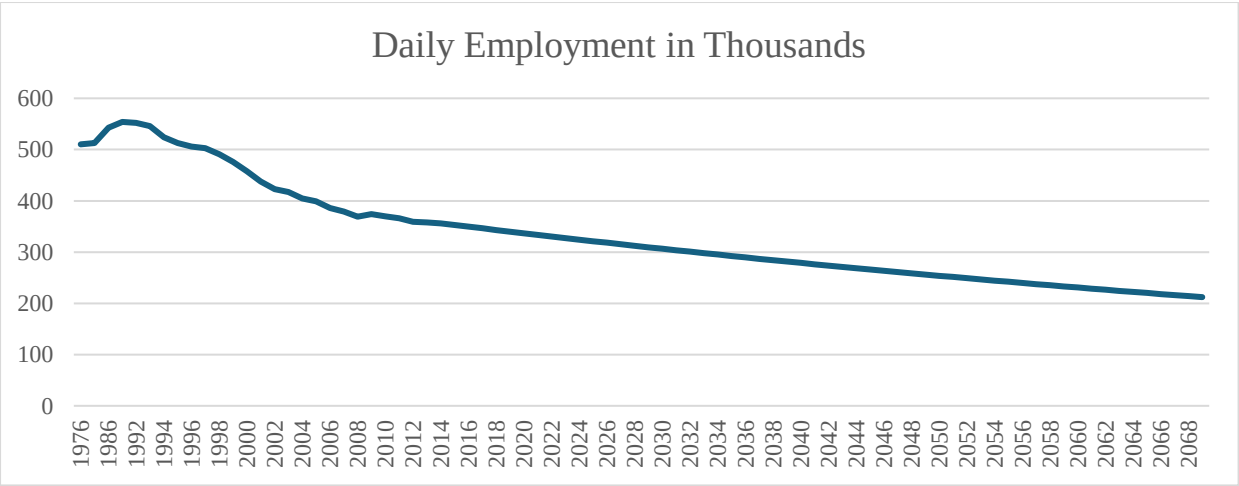


Figure 14 Projected employment trend in coal sector given the technological development

9. Net Job Loss or Gain from Renewables Visa Vis Coal Phase Down

Based on our macroeconomic model exercise dealing with employment and coal production trade-offs, coal sector productivity from 1976- 2015, it emerges that the employment multiplier effect of coal based thermal capacity installation is 1.13. This implies that for every coal-based capacity unit reduction in the Indian Economy, employment will fall by more than 1 unit and will be around 1.13. If the declining trend of employment productivity owing to the capital intensification of the sector and declining labour intensity of the coal production is included, the impact on employment effect from a coal phase down will be much higher than 1.13. The multiplier effect of renewable energy on employment is 1.12. Therefore, if in the future, 1 unit of coal-based thermal power capacity installation is reduced and replaced by 1 unit of renewable-based capacity, then the net decrease in employment is more than 0.01. This increase further can be disaggregated into different segments of jobs based on skill profile as a future scope of investigation.

This rise in employment by 1.12, from the renewable energy sector means that if there is a 16% rise in installed capacity of renewables, it would lead to a rise of 18% in green job creation. This does not automatically translate to employment. The economy will need some time to realise the potential of job creation towards employment which needs to be further explored in a dynamic simulation in the future. Reskilling, training, relocation and rehabilitation of labour would require to be addressed for transition to employment. This entails that almost for this 18% increase in job creation from 16% rise in new renewable energy capacity, 2.38 lakhs jobs in grid connected solar PV, 80000 jobs in off grid solar, 52000 new jobs in the wind sector, 35000 new jobs in the liquid biofuels, 58000 new jobs in solid biomass, 17000 new jobs in solar heating and cooling, and 85000 new jobs in the biogas sector will be created. Over here, job creation and employment has been used interdependently in our macro model.

Therefore, our modelling analysis shows that at the current state of the economy a unit change of coal-based reduction or phasing and its conversion to renewable energy based capacity creation in the economy does not lead to enough net benefit to the economy. The net loss to the economy is of – (-1.13+1.12) = -0.01. This clearly indicates that, coal phase down in the current state and with the ongoing capital intensification and labour productivity fall within the sector will only have the possibility of creating an informalisation and negative impacts on employment for the future coupled with welfare losses. This establishes the need for a timely policy intervention to address such a welfare loss of the economy. This is further substantiated by a macroeconomic social accounting matrix developed by us (ACPET) which indicates and highlights how various macroeconomic sectors and households are impacted by this net welfare loss of the economy arising from coal phase down.

Table 2 Social accounting matrix-based assessment of macroeconomic impacts of coal phase down for the Indian Economy

	Agriculture & Forestry	Coal	Natural Gas	Crude Oil	LPG	Kerosene	Petrol	Diesel	Other fuels	Industry	Electricity	Services	Unskilled labour	Skilled labour	Capital	r1	r2	r3	r4	r5	u1	u2	u3	u4	u5
Agriculture & Forestry	-0.030	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	0.000	-0.001	-0.001	-0.001
Coal	-0.001	-0.011	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural Gas	0.000	0.000	-0.010	-0.001	-0.001	0.000	-0.001	0.000	0.000	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crude Oil	-0.001	-0.001	0.000	-0.012	-0.007	-0.008	-0.008	-0.008	-0.008	-0.002	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LPG	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kerosene	0.000	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Petrol	0.000	0.000	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diesel	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.011	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other fuels	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.011	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industry	-0.042	-0.033	-0.023	-0.091	-0.073	-0.077	-0.077	-0.078	-0.078	-0.124	-0.053	-0.027	-0.004	-0.002	-0.008	-0.001	-0.001	-0.002	-0.003	-0.005	-0.002	-0.003	-0.004	-0.006	-0.007
Electricity	-0.001	-0.001	-0.001	-0.002	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.013	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Services	-0.002	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.012	0.000	0.000	-0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unskilled labour	-0.003	-0.006	-0.004	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.001	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Skilled labour	-0.003	-0.003	-0.005	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.005	-0.007	0.000	-0.010	-0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital	-0.006	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
r1	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	-0.002	-0.001	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
r2	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
r3	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
r4	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000	0.000
r5	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000	0.000
u1	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000	0.000
u2	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	-0.010	0.000	0.000	0.000
u3	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.010	0.000	0.000
u4	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.010	0.000
u5	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.010

The above table 2 highlights how the 12 sectors of the Indian economy comprising agriculture, industry, services, energy sectors (comprising of Coal, Natural Gas, Crude Oil, LPG, Kerosene, Petrol, Diesel, and Other fuels), two skilled and unskilled labour sector, one capital, five rural household sectors (differentiated in terms of income distribution where the R3, R4, R5 are the lowest income class households based on NSSO Data), five urban household sectors (differentiated in terms of income distribution where the U3, U4, U5 are the lowest income class households based on NSSO Data) are impacted from the overall welfare loss of coal phase down within the Indian Economy. The sectors and the value addition of the sectors are constructed on the basis of NSSO and MOSPI data with the baseline year of 2011 – 12. The macroeconomic shock of a welfare loss of -0.01 impacts the agriculture sector's economic activity and value creation by -.03 units. Additionally, the industry is also affected by -.042 units; electricity is impacted by -.001 units, services by -.002 units and unskilled labour by -.003 units. Intuitively, this means that a -.01 percentage change in the coal sector through a phase-down activity immediately impacts the industry, electricity, services and unskilled labourers by -0.042%,-.001%, --0.002%, -.003%. In a nutshell, this means that owing to the shock of -.01% from the coal sector, economic activity and value creation from the industry sector, electricity sector, and services sector contracts by -0.042%,-.001%, --0.002%. Owing to this contraction, employment of unskilled labourers further contracts by -.003%. The agriculture sector is closely linked to the coal sector, and hence, it gets impacted by this phase down. The industry sector uses coal-based power as a derived input into their production activities, and hence, any shock to the coal sector as a phase down also sends a ripple effect impact to the industry sector. The coal sector generates various core, peripheral and unskilled labour services associated with the coal mines and coal mine dependent thermal power, industry sector of the economy[8]. Any coal phase down for the Indian Economy sends a ripple effect in terms of the welfare losses from each of these associated sectors which is indicated through our Macroeconomic Social Accounting Matrix Based model. The results of our model also indicates a large possibility of creation of welfare losses in the lowest income classes of rural (R3,R4,R5) and urban households (U3, U4, U5). Hence the empirical and modelling work highlights and throws a large possibility of informalisation within the household sector of the Indian Economy which has a chance of worsening the growing inequality of the country. Therefore, the time is apt to address this informalisation and possible rise of inequality for the Indian Economy in the near future through social safety nets and measures and different labour sector regulations. In the presence of a growing labour productivity loss within the coal sector and rising capital intensity of the coal sector, such labour sector regulations for social security provisions against job losses from coal phase down is imperative as a part of policy discourse in this country.

The next section therefore highlights the landscape of the policy space of labour informalisation, labour sector regulation and social security measures that needs to be pondered upon in the context of future policy making to address employment and job effects of coal phase down in India.

[8] Add the Odisha mine story – the nature and number of skilled and unskilled workers associated with the mines of Odisha

10. Social Security and Social Safety Measures for The Coal Sector

Informalisation from the Coal Sector:

All the activities that are, in law or practice, not covered by formal arrangements are covered under the informal economy. In 2003, the 17th International Conference of Labour Statisticians (ICLS) spelled out into categories based on the expanded concept (WIEGO, 2012). The categories are given below:

- **i.** Own-account workers in their own informal sector businesses (self-employed with no employees)
- **ii.** Employers (self-employed with employees) in their own informal businesses
- **iii.** Contributing family workers, regardless of the kind of business
- **iv.** Members of informal producers' cooperatives (not established as legal entities);
- **v.** Workers or employees with informal jobs as defined according to the employment relationship (in law or in practice, jobs not subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits (paid annual or sick leave, etc.)
- **vi.** Own-account employees engaged in production of goods for own final use by their household.

In 2003, the ICLS defined, "informal employment is employment without legal and social protection both inside and outside the informal sector." The informal employment can be categorised into self-employment and wage employment. The various activities that come under self-employment and informal wage employment are portrayed in the figure given below:

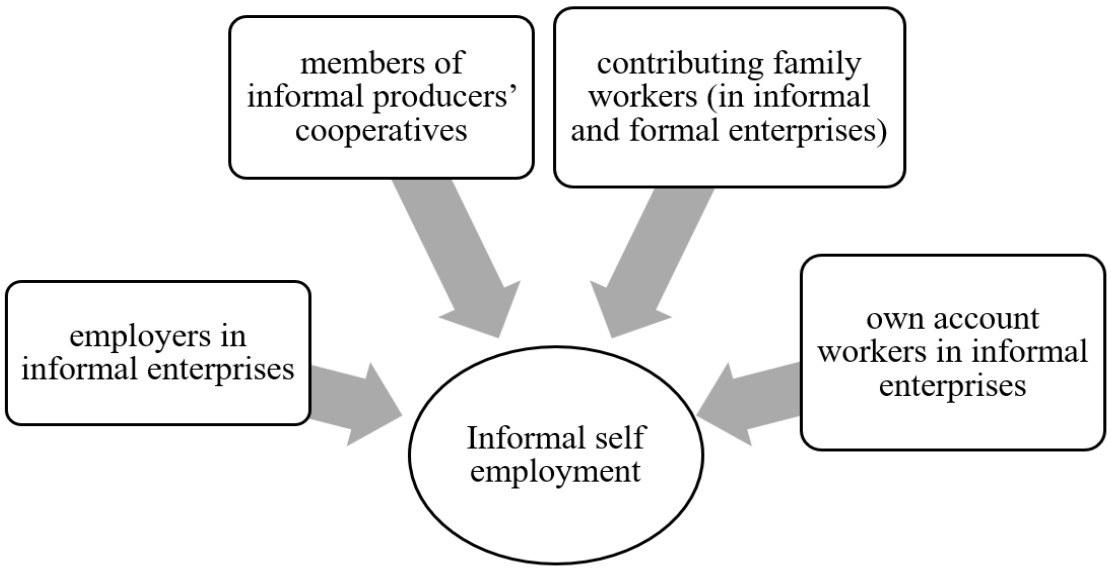


Figure 2: Informal Self Employment
Source: (WIEGO, 2012)

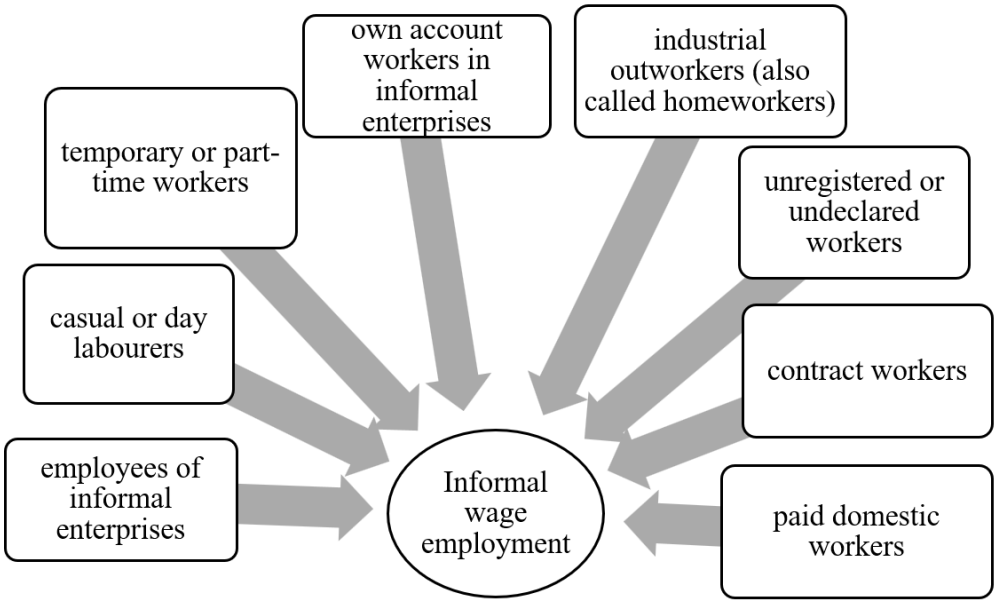


Figure 3: Informal Wage Employment
Source: (WIEGO, 2012)

As the notion of the informal sector was refined, schools of thought like as the dualist, structuralist, and legalist schools of thought began to emerge by examining the characteristics and nature of the informal sector. Some ILO members in the 1970s belonged to the dualist school, which held that the informal sector contained marginal or peripheral businesses that had nothing to do with the official sector. The informal sector is sometimes described as the underprivileged part of a dualistic or segmented labor market, with the majority of its workers being self-employed, because it functions independently of the economy (WIEGO, 2012). According to the structuralist school, the informal sector was a byproduct of capitalist growth. The formal sector is seen to be in charge of the informal sector and to take use of it in order to lower labor and input costs and boost the competitiveness of big businesses (WIEGO, 2012). The formal sector seeks to find low-cost goods and services in its quest for capitalist expansion, which makes informal wage workers subservient to formal economies (WIEGO, 2012). According to the legalists school of thought, which was supported by Hernando de Soto and others, the informal sector is made up of microbusiness owners who attempt to evade the expenses and obligations of official registration because stringent regulations and fees discourage private enterprise and push it underground (WIEGO, 2012).

All the above contextualisation also holds true for the coal sector and there is a potential of the coal sector leading to larger informalisation from future phase down activities. Hence, there is an important need for labour sector regulations to address the employment and job-related impacts from the phase down of the coal sector.

Role of Labour Regulations in Addressing the Employment, Job Impacts on The Coal Sector

In order to understand the role of labour regulations to address the impacts of job losses from the future coal phase down activities, one needs to understand from the international context first.

International Context:

“Labor regulation” includes all legislations, institutions and policies related to labor welfare. Its need and importance had been highlighted by the International Labor Organization (ILO) in terms of a noble effort of labor reform. Chile is one of the countries that took key initiative in the labor welfare field during 1980-1990. The initiative intended to increase labor market flexibility and reduce the instances of labor disputes. Chile has traditionally engaged in providing employment security in terms of advanced notice to workers in case of imminent dismissal. Restrictions were imposed on the use of fixed-term labor contracts. There was also provision of severance payments in case of dismissal (Edwards, S., & Edwards, A. C., 2000).

Moreover, with the intention to create better employment and income opportunities along with promoting social protection measures, a novel social dialogue was initiated in ILC 2002. The social dialogue talked about four pillars of decent work that are employment, social protection, social dialogue, and rights. Argentina presented explicit strategy towards reversing informality. They have successfully curbed the trends of informality. Between 2004 and 2007, unregistered salaried employment fell from 43% to 39% in the midst of robust employment growth. However, in many Latin American countries, the informal economy grew during the 1980s and 1990s due to economic downturns and stagnating growth. But by the 2000s, formalization had increased in Brazil. Further, many countries have come forward to frame various laws concerned with the informal workers. Bolivia, Hong Kong (China) and Peru have introduced domestic workers for drafting specific legislation with the objective of providing legal rights. Similar to this, in Saudi Arabia, a bill was passed in 2009 granting more rights to domestic workers who had previously been removed or excluded from most labor laws.

In India, the Unorganized Workers’ Social Security Act adopted in 2008 aims to frame policy for domestic workers. It provides for self-registration of workers with a view to receiving labor benefits. In India, the Contract Labour Act, and the Inter-State Migrants Act provide that both the principal employer and the contractor who recruits workers or outsources production are “jointly and severally responsible” for complying with labor legislation. There are instances from South Africa where the Durban municipality portrayed good practice to tackle the ongoing struggle that street vendors face. The Self-Employed Women’s Union (SEWU), launched in 1994, and the Informal Trade Management Board, established in 1995, lobbied and negotiated with the Durban local authorities to obtain infrastructures for street vendors.

In 2004, India enacted a national policy which represented a shift from prohibition to regulation. In 1989, the Indian supreme court affirmed that street vendors were allowed to sell products. It aims to legalize street vending by providing for legal vending zones, establishing fee-based regulation rather than a limited number of licenses, promoting the organization of street vendors, and implementing participatory mechanisms, amongst other initiatives. The question is whether any of these regulations can provide a learning framework to devise a labour regulation framework which can deal with the potential job losses from coal phase down.

Forced labor is another area that require significant attention. In Brazil, a Special Mobile Inspection Unit was introduced in 1995, consisting of a flying squad of labour inspectors and federal police officers who investigate allegations of forced labor on rural farm estates. As per the reports, this initiative has proven successful, freeing more than 32,000 enslaved workers. In Italy, the Ministry of Labor's Carabinieri Command for the Protection of Labor is responsible for overseeing the implementation of social security and labor laws. Its duties include combating illegal and covert employment, and the eradication of cruel working conditions. Trade unions have been actively advocating for the extension of social security programs to the informal economy in the Philippines, Brazil, and Thailand. If India,

has to work out an employment and job loss rehabilitation program from coal phase down, it might like to borrow from the above international frameworks.

Once it has borrowed from the international contexts and frameworks, the national context of a social security framework of addressing job losses need to focus on the following elements – a) Social Security and b) Minimum Wages. Social Security needs to be seen from the parlance of what happens to the people who lose their jobs from a potential coal phase down. The minimum wage segment needs to see whether the coal workers can get a minimum wage to maintain their lifestyle or if they are displaced to any other sector then they are assured of a minimum wage in the associated sectors where they go after being displaced due to the coal phase down. These two elements have to be substantially focused. The next section brings out some of the perspectives from the above two lens.

11. National Context: Addressing the Impact on The Labour of The Coal Sector From Two Perspectives – Social Security, Minimum Wages

It is eminent that while talking about India, owing to coal phase down, job losses and informalisation can emerge upon and emanate from the coal sector. These workers from the coal sector needs to be either protected through social safety measures as otherwise they will migrate or create a larger unorganised informalisation if they are not skilled enough to get absorbed in the other similar and associated sectors. The state of Odisha has created such an integrated planning process where displaced coal workers can move into the other sectors of the economy through requisite skilling, reskilling processes.

However, currently the informal workers of the coal sector are not sufficiently covered under the social security net. Many of the informal workers are employed in hazardous and exploitative conditions because there is little regulatory oversight. In 2020, the International Trade Union Confederation ranked India as one of the top ten nations in the world for worker rights. Even after the Unorganized Workers Social Security Act (UWSSA) went into effect in 2008, not much progress had been made in developing accessible and efficient social security programs for unorganized workers in the unorganized sector. The Code on Social Security, for the most part, largely borrows directly from the UWSSA and does not go into detail about the scope, nature, or funding mechanism of the social security schemes. In addition to this, there have been many commendable efforts to address the challenges that are being faced by informal workers and ultimately come out with solutions. The best thing India can adopt is the frequent conduction of national labor conferences related to coal phase down impacts on the labour and other associated sectors so that the policymakers and the concerned stakeholders would be aware of necessary policy changes that need to be implemented. The ILO has taken many initiatives considering the struggles that are being faced by the informal sector. In the Indian context, such a peripheral informalisation can easily happen around the coal sector. It is commendable that many developed countries are successfully implementing labor policies for the coal sector which can face job losses from coal phase down catering to key areas like social security, and minimum wages. This requires continuous evaluation of minimum wage, social protection programs combining both the aspect of social assistance and social insurance.

In the next segment, a little deeper analysis into **Social Security and Minimum Wages is being attempted from the context of the coal sector led phase down and informalisation.**

Social Security: According to Article 22 of the Universal Declaration of Human Rights, "Every one, as a member of society, has the right to social security," social security is a fundamental human right. In order to ensure protection against the lack of work-related income (or insufficient income) that may result from illness, disability, maternity, employment accident, unemployment, old age, or the loss of a family member, social security covers all measures that provide benefits, whether in cash or in kind. Unavailability, may also include lack of access to health care, insufficient family support, particularly for children and adult dependents, along with general poverty and social exclusion.

The majority of the Indian labour market is informal. Approximately 90% of the workers in India's labor market have informal employment in 2018–2019. The current labor laws, social protection programs, and other employment benefits either do not cover these workers at all or only cover them insufficiently. In India, the Government of India (GoI) formed the National Commission for Enterprises in the Unorganised Sector (NCEUS) in 2004 to examine the problems encountered by businesses in the informal sector extensively and offer solutions. The report asserted the need for social security, and it would act as a shock absorber during socio-economic shocks. As a result of this, there have been many initiatives to provide comprehensive social protection to the informal workers. In developing nations like India, social security is best understood as pro-poor policies that can be preventive, like provident funds; promotional, like the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), which aims to increase income; and protective, which aims to provide relief from specific external shocks, like compensation offered through insurance schemes in the event that a primary breadwinner is injured or dies. Even though India's informal sector is quite extensive, the majority of social security benefits are still only available to those in formal organizations. If we look at the statistic regarding promotion of social security in terms of availability of any social security, eligibility for paid leave, and having a written job contract (Table 1) it is hardly more than 30%, which is significantly less. This is a startling position and needs to be kept in mind while designing the social security benefits for any worker who might be impacted from the coal phase down in India.

Table 1: Informal workers with social security benefits

All India	Availability of social security benefits (%)	Eligibility for paid leave (%)	Has written job contract (%)
2011-12	23	28	21
2018-19	26	29	19

Source: Centre for policy research (2020)

While designing social security benefits for the coal sector in India, India can learn from the experience of Ghana, Cambodia, Thailand, Rwanda, Phillipines and Bangladesh. Ghana has put in place measures to guarantee the informal economy's access to social security. While social insurance coverage has gradually expanded in Thailand, low-cost methods are being implemented in Cambodia to enhance health and safety in informal enterprises. Similar models can be tried and tested in the context of the coal sector phase down in India.

Workers in the informal economy are not covered by social security. Lack of social protection is one of the main causes of poverty and social exclusion. However, because employees and businesses in the

formal economy are required to bear the entire cost of financing the social security system through taxes or social insurance, its effects are also felt in the formal economy. In 2003, domestic workers in South Africa were covered by the Unemployment Insurance Fund (UIF). The fund covers all domestic workers, including housekeepers, gardeners, domestic drivers, and anybody who looks for someone in the home. It also offers unemployment, maternity, and adoption benefits, as well as compensation in the event of illness or death. Employers are required to register their employees and make contributions. Similar to this, national health insurance has been introduced in Ghana, Rwanda, and the Philippines with the goal of granting everyone accesses to extensive benefit packages. In 2002, Bangladesh's "Targeting the Ultra Poor" (TUP) program was introduced. The program integrates income and asset transfers that are connected to livelihood skills training, health promotion, and other social programs that have the ability to empower and transform. In India, the 2008 Unorganised Workers' Social Security Act provides legislative support for a series of pre-existing social security and welfare schemes. The question whether this can be leveraged to design a framework for the coal phase down led informalisation and job losses for India. Further, on the recommendation of the Second National Commission on Labor's recommendations, the Ministry of Labour and Employment (MoL&E) classified labor legislation into four "Labour Codes." The four Labour Codes are the Code on Wages, 2019, the Occupational Safety, Health and Working Conditions Code, 2020, the Code on Social Security, 2020 and the Industrial Relations Code, 2020 (Farooqui & Pandey, 2020).

Minimum Wages: Minimum wages are "the minimum amount of remuneration that an employer is required to pay wage earners for the work performed during a given period, which cannot be reduced by collective agreement or an individual contract." In reducing labour income inequality, minimum wage fixation plays an important role. It further helps to align real wages with productivity growth by coordinating macro-level wage rises with inflation and output measures. The need for adequate minimum wages to protect workers is important in the absence of effective collective bargaining. By increasing the relative earnings of low wage workers, minimum wages diminish wage and income inequalities and the gender wage gap. Globally, if we look at statistic of wage earners distribution who are getting less than minimum wage, a huge disparity could be seen regionally.

In Africa it is 21%, America 17 %, Asia and the Pacific 16 % and Europe and Central Asia 13 % and about 3.1 per cent of wage earners globally, or around 57 million individuals, live in countries without minimum wage systems. The regions with the highest proportion of wage earners without minimum wage protection are the Arab States (52 %) and Africa (21 %). The Government of Cyprus introduced the first national minimum wage in August 2022. Similarly, the construction industry's collective bargaining agreement in Spain, was signed in 2017 and revised in 2022, governs results-based compensation by emphasizing productivity as being essential to the industry's expansion. The agreement includes productivity bonuses or incentives, linking higher work yield to proportional increases in pay compared with standard levels. A bipartite Sectoral Productivity Commission is also established by the agreement to supervise the establishment and approval of wage scales. The hospitality industry's collective bargaining agreement in North Macedonia outlines how performance-based compensation is to be distributed, with the possibility of earning up to 30% more than the base salary. A five percent pay increase is given for each criterion that is satisfied. Performance-based pay is based on a number of factors, including the timely completion of Argentina's work activities, labor productivity gained, process savings, efficiency in using working hours, volume of work performed, and quality of work performed. Additionally, the agreement calls for a base compensation increase contingent on the business's overall performance.

The question is whether the coal sector of India can learn from these instances and devise, design a mechanism and framework for addressing the job losses from coal phase down activities in India

12. Way forward:

Given the important role played by electricity in steady state growth of the Indian Economy, ensuring adequate, uninterrupted electricity supply will require a balanced approach towards coal phase down. The discourse above highlights the challenges in transition to clean energy. There has to be a realistic assessment of the time it will take for renewable energy sources like Solar and Wind and Nuclear to be able to take over the role of Thermal Power Plants, while meeting the growing demand for electricity. This would help plan for timely welfare measures and repurposing of assets and rehabilitation of various stake holders of the Coal Economy.

Certain essential areas of future study required would include

a) A dynamic energy demand model that translates to coal demand and captures latest developments like increase in deployment of EVs, Data Centres, increase in Manufacturing share GDP, Industrial Corridors, and so on.

b) Profiling all aspects of potential Coal supply from domestic sources, in juxtaposition with quality of coal, cost of evacuation and transport etc. to help develop a framework for prioritization of coal mines closure. A related activity would be broadly understanding effective cost of coal for various TPPs based on coal linkages.

c) Studying the nuances of impact of increase in share of renewable energy on demand for coal, utilization of Thermal power plants and grid related issues. RES like Solar and wind is concentrated in few states. Increased dependence on import from grid and associated costs and reliability issues must be fully fleshed out to avoid disruption in economic activity.

d) Impact of energy efficiency in generation on coal demand across sectors of the Indian Economy needs to be examined as this could help sustain a valuable domestic source of cheap power (coal) for a longer period without compromising on emission targets. This would include scenario building of impact of technological efficiency like Advanced USC power plants, efficiency enhancing technologies in Manufacturing and Services sectors etc

e) Impact of coal demand reduction (CIL, Non-CIL) on economy in general and coal producing states in particular needs to be established. Mitigation measures to address Socio Economic costs- of Centre (including Railways) and state revenues, employment, household incomes of direct and induced labour need to be identified, and templates have to be developed for planning timely action for minimizing adverse socio-economic impact.

f) The build-up of non-fossil fuel based power sources- wind, solar, nuclear with associated battery energy storage systems and transmission infra will generate need for faster immediate financing and investment. Clear projections of potential for creating this capacity and generation, under various scenarios, in terms of technology, domestic capability, import reliance, gestation period, financial sources and economic efficacy need to be developed, with timelines for smooth transition to clean energy and Coal phase down. These alone would give clear picture on how and when coal phase down could be planned towards 2070 Net Zero path, without adverse impact on India' growth targets.

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