Energy Transition in India: Uncovering the Darkness beneath the Lamp for the Power Industry: A Critique

Uma Sankar Khan [a] * Avik Sinha [b, c],

[a] *Technical Advisor (Process), KBR, India*
[b] *Centre for Excellence in Sustainable Development, Goa Institute of Management, India*
[c] *Adnan Kassar School of Business, Lebanese American University, Beirut 1102-2801, Lebanon*

Abstract

Innovation-led developmental policies for environmental fortification might bring the social aspects of sustainability at a crossroads. While innovation can bring improvements in environmental quality by initiating energy transition, it might be responsible for creating unemployment issues. Now, the prevailing policy directives cannot bring the best of the two dimensions. Rather the directives should investigate minimizing the tradeoff being created by the innovation. The present study analyzed this aspect of innovation from a theoretical perspective, followed by assessing the status quo of the Indian Power Industry. A set of policy recommendations have been provided following the critical assessment.

Keywords: Energy transition; Innovation; Power industry; India; Tradeoff

Email address: U.S. Khan (umasankar.khan@kbr.com); A. Sinha (f11aviks@iimidr.ac.in),

1. Background

Climatic shift is a pressing policy concern for global, as well as Indian policymakers. The Carbon Dioxide (CO_2) emissions in India have increased by nearly five times in the last three decades (refer Figure 1). This appalling rise in the level of emissions can have severe negative consequences on the sustainable development agenda of the nation. This issue has been reflected several times in the policy discourse. Discussions on this issue have revolved around the non-attainment of the SDG 13 objectives. The *State Energy & Climate Index* report published by NITI Aayog (2022) stresses on this issue. The possible solutions indicated by the NITI Aayog officials include Carbon Capture Utilization and Storage and introducing decarbonization technologies for curbing industrial emissions.

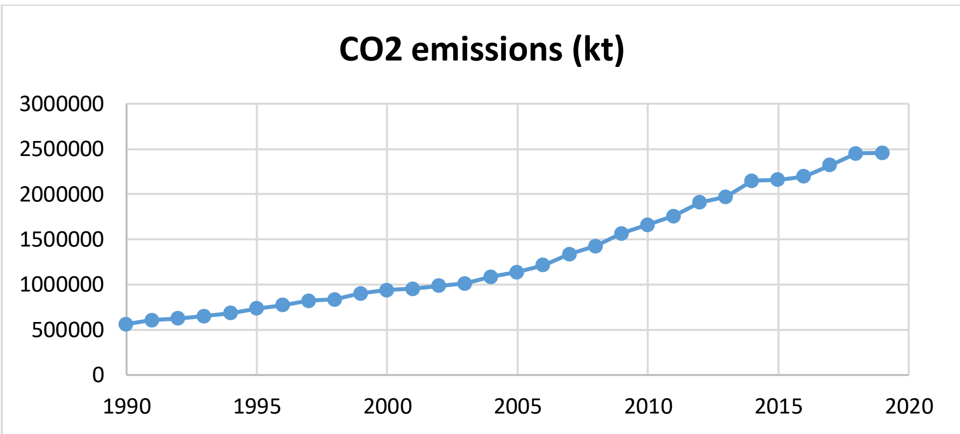

Figure 1: Trend of CO_2 emissions in India (Source: World Bank, 2023)

Nevertheless, considering only the supply-side dynamics of the problem might make these policies ineffective. The CO_2 and other Greenhouse Gas (GHG) emissions are caused by the incessant usage of fossil fuel-based energy sources, and encountering this predicament will entail an effective transformation of these energy sources. The COP26 discourse was much focused on deliberating this solution as an answer to the climatic issues (IRENA, 2021). In keeping with the global energy transition pathway, the Indian government has also started embarking on promoting energy transition initiatives. The Union Budget 2023-2024 has reflected this initiative. The schemes like *Green Hydrogen Mission*, *Energy Storage*, *Energy Transition*, *Renewable Energy Evacuation*, and *Green Credit Program* indicate the mission of Indian government to promote green growth (India Infoline, 2023). It is well understood that the operationalization of these schemes will require technological development towards the discovery of alternate energy solutions. These solutions are largely aimed at replacing fossil fuel solutions with green energy solutions. Development and diffusion of these solutions might assure the greening of the Indian economy by reducing the level of emissions in the ambient atmosphere.

While these solutions might pose a rosy picture on the policy front, the social inefficacy of these schemes is largely ignored. Development of a technological solution as a substitute for an existing solution will have economic, environmental, and social effects. While the Indian policymakers are concerned about the first two effects, the third effect is largely remaining unfocused. The technological developments toward bringing overhaul in the Indian power industry might open avenues for renewable and more efficient energy solutions. However, these solutions will be substituting the traditional fossil fuel-based energy solutions. This gradual substitution will most likely be accompanied by the removal of the subsidies on fossil fuels and subsidizing of renewables. This exercise will eventually increase the price of fossil fuel solutions, leading to a contraction of their demand. This demand contraction will then be reflected in the cash flows of the fossil fuel power generation firms. Apart from them, the firms along the upstream and downstream of the supply chain will also face nearly similar consequences. The cash flow shrinkage will translate into shrinking profit margins, and hence, it will be difficult for these firms to retain employees. So, the traditional fossil fuel-based power generation industry will start experiencing a rise in unemployment. This scenario can be referred to as the classic "*Capital-Labor Substitution*" principle, as explained by Arrow et al. (1961). Additional capital investment being translated into technological capital will start replacing manual labor. So, the technological solutions aimed at sustaining the energy future of India might cause a serious predicament in the way of achieving the desired sustainability.

Achievement of the developmental policy objectives can be critical because of the existence of such tradeoff scenarios. The simultaneous neutralization of the externalities by the policy instruments might be a challenge behind the development of a suitable policy framework. Hence, the policy framework should be revised in a way so that the optimal policy response can be attained.

2. Theoretical Model

Impact of innovation on emissions and unemployment does not happen simultaneously, it take time to evolve. This impact can be explained in a phasewise manner. During the development phase of the technological solutions, a gradual rise in its acceptability might result in a rise in emissions at a decreasing rate. Therefore, the emissions will reach a peak after a certain period, and then they will start declining. On the other hand, the development of these technologies will attract more laborers. Once these technologies are developed and diffused, they will enter the maintenance phase. This is when the demand for laborers will start declining. So, it can be assumed that innovation will continue to play a dichotomous role in shaping sustainable development scenario in any nation, as it brings the ecological and social dimensions of sustainability into a tradeoff scenario. The theoretical model needs to accommodate this aspect of dichotomy.

Theoretically, this scenario can be explained in terms of the mathematical expression of the generally accepted form of Environmental Kuznets Curve (EKC) hypothesis (Grossman and Krueger, 1991). As the EKC hypothesis can capture the evolutionary impacts of the explanatory variables over a period, the impacts of innovation can be assumed to follow an evolutionary path.

This entire scenario can be represented in the following mathematical forms:

$$\mathrm{CE}_{i,t} = \alpha_0 + \alpha_1 \mathrm{INN}_{i,t} + \alpha_2 \mathrm{INN}_{i,t}^2 + \sum_m \alpha_m \mathrm{X}_{m_{i,t}} + \varepsilon_{i,t}$$

(1)

$$\mathrm{UE}_{i,t} = \beta_0 + \beta_1 \mathrm{INN}_{i,t} + \beta_2 \mathrm{INN}_{i,t}^2 + \sum_n \beta_n X_{n_{i,t}} + \Theta_{i,t}$$

(2)

Here,

CE = CO_2 Emissions

UE = Unemployment

INN = Technological Innovation

X = Matrices of additional explanatory factors

ε, Θ = Stochastic errors

i = Cross-sectional units

t = Temporal units

The turnaround points of these two curvilinear associations will occur at $-\alpha_1/2\alpha_2$ and $-\beta_1/2\beta_2$. These points are the respective global maxima of these quadratic associations, and they might be considered as the thresholds, where the impacts of innovation are expected to change their directions.

Now, the dichotomous role of technological innovation explained in these two associations can be revealed by equating their respective first-order conditions to zero:

$$\mathrm{INN}_{i,t} = \begin{cases} \alpha_1 > 0, \alpha_2 < 0, \therefore -\alpha_1/2\alpha_2 < 0 \\ \beta_1 < 0, \beta_2 > 0, \therefore -\beta_1/2\beta_2 > 0 \end{cases}$$

(3)

Eq. (3) reveals that the coefficients innovation and squared innovation are opposite for CO_2 emissions and unemployment associations. Therefore, the directionalities of the associations will also be opposite. The innovation-emissions association is expected to follow an inverted U-shaped pattern, while a U-shaped pattern is expected for the innovation-unemployment association. This entire scenario can be depicted in Figure 2.

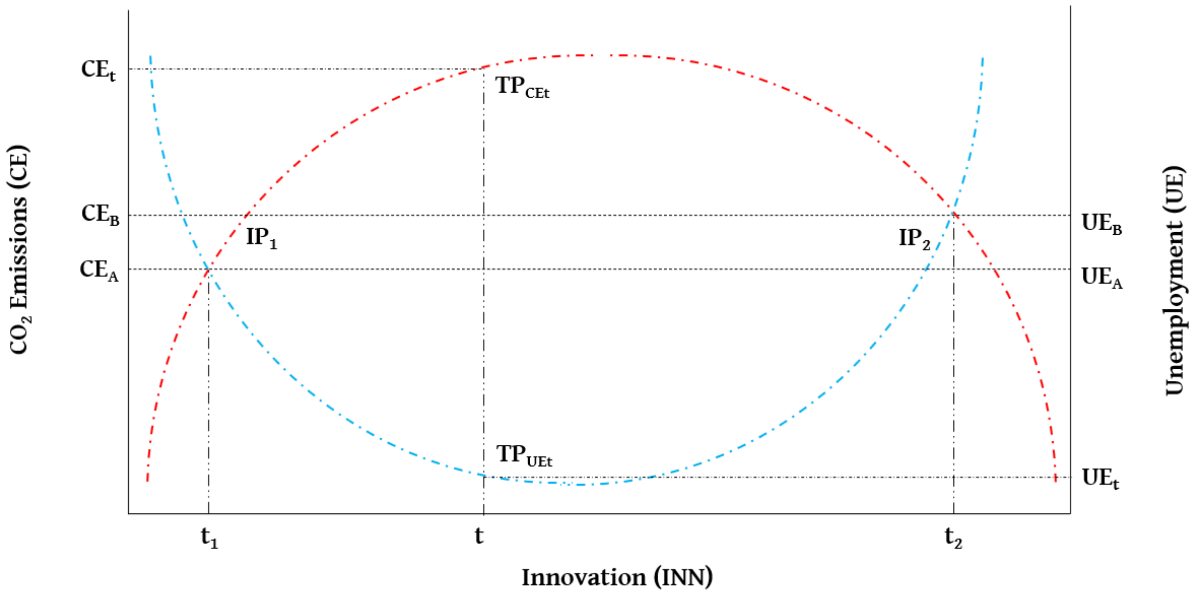

Figure 2: Socio-Ecological Tradeoff Initiated by Technological Innovations

These two concurrent associations will intersect at two points [IP_1, IP_2] as indicated in Figure 2. The respective CO_2 emissions and unemployment levels {CE_A, UE_A} and {CE_B, UE_B} are also indicated in Figure 2. The time *t* is hypothesized to exist between t_1 and t_2. IP_1 is hard to predict as the technological solutions are at the developmental stage with falling unemployment. Also, CO_2 emissions are increasing at a decreasing rate. Hence, apparent expected outcomes might create a short-run policy myopia. The problem might start to emerge in the vicinity of the turnaround points of the respective associations. If the turnaround points are reached at t^*_{CE} and t^*_{UE} for innovation-CO_2 emissions and the innovation-unemployment associations, then the scenarios at the maximum and minimum points of these associations can be expressed as $\lim_{t \to t^*_{CE}} \frac{\partial CE}{\partial INN}\Big|_t = 0$ and $\lim_{t \to t^*_{UE}} \frac{\partial UE}{\partial INN}\Big|_t = 0$. The expected directional changes in these associations can be expressed as:

$$\frac{\partial CE}{\partial INN}\Big|_{t=t^*_{CE}} > \frac{\partial CE}{\partial INN}\Big|_{t=t_2} \quad (4)$$

$$\frac{\partial UE}{\partial INN}\Big|_{t=t^*_{UE}} < \frac{\partial UE}{\partial INN}\Big|_{t=t_2} \quad (5)$$

These conditions resonate with the conditions outlined in Eq. (3). As these two associations might change their directions beyond their respective turnaround points, unemployment will start rising against the reduction in CO_2 emissions. It is also important to observe that unemployment was reduced at the cost of environmental quality before the appearance of these two turnaround points. So, the socio-ecological tradeoff will exist throughout the coexistence of these associations. The policymakers will be unable to achieve the maximum potential benefit from any of these two dimensions. Henceforth, they need to focus on the second policy intervention point IP_2.

Considering the overlap between the two associations, the optimum level of innovation (i.e., INN*) can be denoted as the following:

$$\mathrm{INN}^* = \max\left[\left\{-(\alpha_1 - \beta_1) \pm \sqrt{(\alpha_1 - \beta_1)^2 - 4(\alpha_0 - \beta_0)(\alpha_2 - \beta_2)}\right\}/2(\alpha_2 - \beta_2)\right] \qquad (6)$$

Here, $\alpha_0, \alpha_1, \alpha_2, \beta_0, \beta_1, \beta_2 \neq 0$ and, $(\alpha_1 - \beta_1)^2 \geq 4(\alpha_0 - \beta_0)(\alpha_2 - \beta_2)$

The maximum of the two points achieved in Eq. (6) indicates IP_2. This point indicates a policy optimal between CO_2 emissions and unemployment. Policy interventions are required to stay at this point by maintaining the socio-ecological equilibrium.

3. Discussion

The brief discussion on the theoretical aspects of the associations reveals that the socio-ecological tradeoff can be brought forth by innovations. It is inevitable in the Indian power industry. Any policy initiative towards promoting green growth through energy transition will bring forth social imbalance by increasing the pressure of unemployment. As a result, the Indian economy might enjoy short-run economic benefits of the energy transition. But the long-term consequences might be visible in the decline in aggregate demand, as the rise in unemployment might gradually reduce the level of per capita income, and thereby, the disposable income. So, the Indian policymakers will have two questions in front of them:

a. Should India achieve energy transition at the cost of employment?

b. Should India retain employment at the cost of environmental quality?

These two questions are at two extreme ends of the spectrum of sustainable development. The lack of a participatory approach in the policymaking front might be attributed as a reason behind this issue. The recent annual review report on *Renewable Energy and Jobs* published by IRENA (2022) has shown that the growth in the renewable energy job market is way behind the job cuts in the non-renewable energy job market. Confusing substitution as creation might create a blind spot in the policy directives. Total employment in the Indian Petroleum Industry (see Figure 3), shows that employment is gradually shrinking in this industry. A similar kind of scenario is also visible in the case of the Indian Mining Industry (see Figure 4). Although the Indian government promises to create substantial jobs in the renewable energy field by 2050 (Press Trust of India, 2022), the figures do not add up.

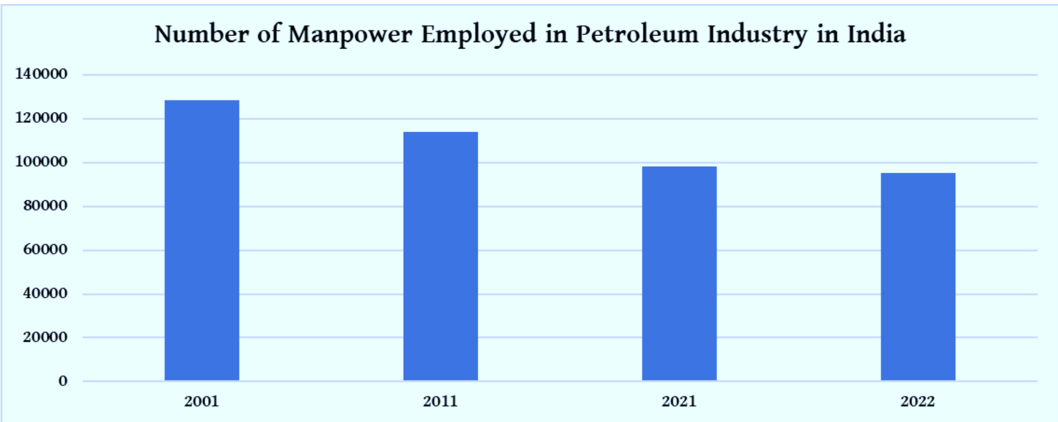

Figure 3: Number of Manpower Employed in Petroleum Industry in India

(*Source: Ministry of Petroleum & Natural Gas, Govt. of India*)

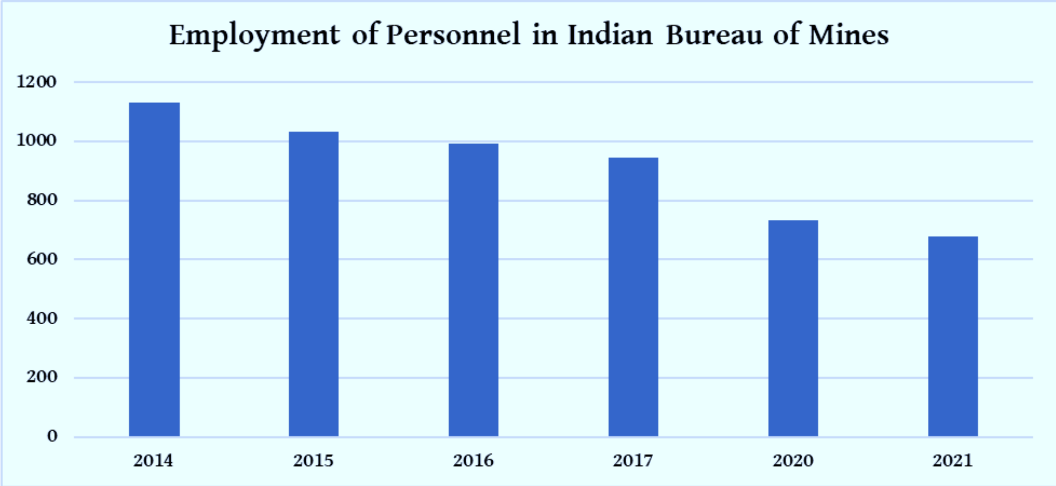

Figure 4: Employment of Personnel in Indian Bureau of Mines

(*Source: Ministry of Mines, Govt. of India*)

Although the plan seems ambitious, it is not unachievable. In the latest assessment report, *International Labor Organization* (2022), clearly states that the creation of jobs in the renewable energy industry needs *Holistic Policy Packages*, and a substantial amount of the same should be attributed to quality education. Now, this education is not only limited to primary to tertiary education, but also rehabilitative education and training of the existing workforce. However, the prevailing education budget in India might not be commensurate with this demand. The trend of the Indian Public Education Expenditure in Figure 5 shows that the budget allocated for education is even lower than the *Millennium Development Goal* regime. It might prove to be difficult to carry out skill development and training with such shrinkage in the education expenditure. Moreover, institutionalizing the innovation-led energy transition initiatives requires reaching the grassroots level, and creating an environment of environmental awareness. Sustaining a policy solution requires the participatory role of the households. However, the existing energy and educational policies might be facing the issue of mistargeting and misallocation in this case.

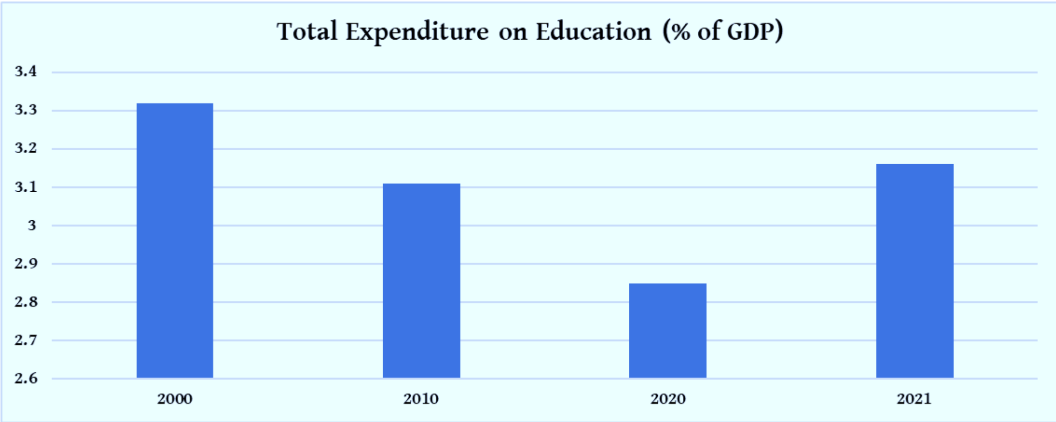

Figure 5: Total Public Expenditure on Education as percentage of GDP

(*Source: Ministry of Human Resource Development, Govt. of India*)

4. Conclusion

The answer to both the questions will lie in how the unemployment issue will be handled. One of the fundamental ways to handle this issue might be the rehabilitation of the laborers employed in the traditional power generation industry, as well as with the firms in the upstream and downstream of the supply chain. The rehabilitation might start with providing them with unemployment benefits. However, providing this benefit might give them a sense of security, and consequential fiscal expenditure to be incurred by the government makes it not a viable long-term solution. Hence, the government needs to provide them with necessary skill development and training, so that they can be employed in the other industrial sectors. Enabling them to earn from alternate sources might help in restoring the balance in the economy.

This solution might lead to heavy fiscal expenditure on the part of the government. Some financial intermediations might ease this process. The financial institutions might be directed to introduce the carbon footprint-linked *Differential Interest Rate* mechanism for (a) promoting the energy transition, and (b) upskilling the labor force. The non-renewable energy generation firms might be provided loans and advances with a higher rate of interest, following the *Pigouvian Taxation* principle. This will discourage the firms to continue their existing production process and start embracing the energy transition mechanism. The interest income received by the banks might be channelized to initiate the upskilling and training of the unemployed laborers. On the other hand, the firms might be endowed with interest rate benefits, while the loans are taken for carrying out in-house training and upskilling activities. This process might be considered the first phase of the policy revamp.

In the second phase, the government might start subsidizing renewable energy solutions for household consumers. The amount to be disbursed as the subsidies can be obtained via charging pro-rata interests on renewable energy solutions for the firms. This will help in creating a domestic value chain and taking a first step towards creating awareness regarding energy transition. This step can be strengthened further by amending the educational curricula to introduce the latest technological developments. Educating the future labor force will complement the initiative of creating awareness.

With these two phases being operational, the government can take a step forward towards developing the participatory approach for making the nation ready for the energy transition. The basic premise of the *Holistic Policy Package* lies in assuring inclusivity in the policy dimensions. It is true that the best of both worlds cannot be obtained. But an inclusive policy design can minimize the tradeoff and create an optimum path.

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