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A Policy Proposal for Green Jobs in India

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A Quantitative Analysis on Inclusivity of Green Jobs

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1 Background

The policymakers, particularly on the right side of the aisle, have traditionally stigmatized any form of environmental regulations, as being a detrimental practice, which raises the cost of production, disproportionately affects the small businesses, and imposes expenses on the economy that tend to stifle economic growth and cut levels of employment (Murphy et al. [2015]). So, what this argument does is to essentially juxtapose environmental regulations against the growth and job opportunities in any economy. In the specific context of developing countries, this raises serious concerns about any environmental regulations as these economies are already reeling under problems of severe unemployment and poverty. Therefore, any discussion on clean energy in the context of a developing economy is usually taken with a grain of salt since it somehow tends to generate a feeling among the politicians as well as the policymakers that it will inflict hardships on the economy.

However, with the ongoing research in the field of employment generation through investments in a clean energy programme, opinions are much more favourable to the positive synergies between environmental regulation policies and the increased levels of growth and employment. Recent studies show that investments in renewable energy and energy efficiency not only doesn't slow down the growth process of the economy but also generates net positive jobs in the economy (Wei et al. [2010], Pollin et al. [2015], Pollin [2015]). This is so because the clean energy sector has a higher employment elasticity than the fossil fuel sector per unit of money invested. It is to be noted that there are considerable variations between technologies, with wind power appearing to be relatively less labour-intensive, while solar and energy efficiency investments appear more labour-intensive.

Pollin and Chakraborty [2015], focusing on India, have found substantial evidence for the increased employment impacts of clean energy investment. They have shown employing an input-output methodology that job creation in the clean energy sector is almost twice when compared to the fossil fuel industry.

Moreover, it is important to recognise that the majority of jobs created through investments in the renewable energy and energy efficiency programs will be in the same areas of employment in which people are already working. It signifies that with investments in the clean energy programme there will be no dramatic change in the overall employment structure of the economy. For example, constructing a solar panel will create jobs in the electrical and electronics industry, metal and plastic industry, and truck drivers, among others. Similarly, expanding the public transportation system will employ civil engineers, construction workers, and dispatchers. Hence, for a national clean energy programme to generate these types of job opportunities, it will not be necessary for the government to introduce a distinct new set of vocational training programs that differ significantly from the existing skill development practices in these economies. This does not imply that there will be no skill updating required for these new jobs. A 2011 global survey study commissioned by the ILO, which analysed skill requirements tied to specific green economy occupations in 21 countries, including India, argued that most clean energy and other green economy occupations will require *updating* skills as opposed to training workers for entirely new professions (Strietska-Ilina et al. [2011]).

Another significant aspect of clean energy investments is the inclusiveness of the programme, especially regarding the quality of jobs generated by the programme. It is not only important to analyse the total number of jobs generated in the economy through investments in clean energy, but also the nature of distribution of those jobs around issues of gender, region, skills, etc. In the Indian case, another area of interest will be the division of work based on the caste profile.

To the best of our knowledge, no such macro-study highlighting the composition of employment in the clean energy sector is available for the Indian economy. Pollin et al. [2015] studied the quality of jobs created through investments in the clean energy sector for the economies of Brazil, Germany, Indonesia, South Africa and South Korea. The results obtained by the authors varied substantially by country. The study found a high proportion of employment in informal sectors in Brazil, Indonesia, and South Africa. In all the five countries studied, male jobs profoundly dominated the clean energy sector. It is primarily because of the significant role played by both the manufacturing and the construction of the overall clean energy investments. Notwithstanding these biases, the employment compositions are still significantly less skewed when compared to those in the fossil fuel industry. Given this backdrop, it becomes pertinent to discuss the details of our proposed policy framework.

The paper is divided into six sections. The second section discusses issues of fiscal policy and its effects on growth, employment, labour productivity in a theoretical context. The third section presents the salient features of our proposal. The fourth and the fifth sections present the methodology and results respectively. The last section concludes the paper.

2 Issues of Growth, Productivity and Wages

While our proposal is a combination of public and private contribution to greening the economy, we need to briefly discuss the rationale for fiscal expenditure since it is usually subject to severe criticism particularly in the mainstream literature, both for short and long run. Even in the green growth literature these issues have been raised and has been argued that such fiscal expenditure should be planned in a countercyclical way to avoid overheating in the economy during high demand phases of a business cycle (Blyth et al. [2014]). Moreover, a decline in labour productivity (higher employment elasticities) as a result of green technologies has also been considered as hampering the growth prospects in the long run. In what follows, we counter both these arguments.

2.1 Is Fiscal Expansion Contractionary in the end?

In the mainstream literature, in the short term, fiscal expenditure is assumed to increase interest rates, thereby, crowding out private investment; increase inflation, especially if the economy is working along its full capacity/employment frontier; have no effect on the output since rational agents cut down on their consumption expenditure in anticipation of an increase in taxes in the next period (Ricardian equivalence). In the long term, it is argued that growth rate is either exogenously given by the rate of growth of labour force and its productivity or endogenously determined labour productivity. In either case, demand management policies cannot affect the long run growth since they cannot change the natural rate of growth. In fact by disturbing the incentive system, it harms the efficiency of the economy.

On the issue of crowding out, the route of increased interest rate is flawed because central bank sets the interest rate, which unless changed through policy remains where it was announced before the fiscal expansion took place. As for the issue of inflation, the usual assumption is a fiscal expansion entails 'too much money chasing too few goods'. This argument is erroneous too as the pool of goods itself expands as a result of the multiplier that this expansion sets in motion. In situations, such as full employment or full capacity, where the pool can't be increased, the argument will hold true for any form of expenditure, private investment or consumption alike. So, there's nothing exceptional about fiscal expenditure in that case.

As for the long run, a fundamental problem with growth theories of this variety (supply-side) is that they *assume* that supply creates demand in the long run[1].

In contrast, alternative theories of growth originating from the Kalecki-Keynesian tradition show that capacity utilisation, and hence, the growth rate, is *endogenous* to the system, which is determined by the level of exogenous sources of demand, such as public investment, the 'animal spirits', the multiplier and the technologically given output-capital ratio. Let's look at this issue more closely since it has direct implications for the employment generating capacity of this endogenously determined rate of growth.

2.2 Growth and Employment Prospects of the Green Policy

Unlike the mainstream literature, where the natural rate of growth determines the potential (and actual) rate of growth, in the heterodox literature, the causality runs in the opposite direction. It is the endogenously demand-determined rate of growth, as described above, which determines the natural rate of growth, either through changes in the rate of growth of labour force through immigration n or through changes in the rate of growth of labour productivity m through the Kaldor-Verdoorn law. The first route is a little far fetched in the context of developing economies since they have large internal labour reserves, so, we focus on the second to discuss the employment generating capacities of the green growth programme we profess below.

Since green growth expenditure, which is part public and part private,

[1] In these models investment is equal to the full employment savings by *assumption*. There is no role for expectations, which makes them inapplicable for an economy which is premised on expectations about the markets. As soon as an independent investment function is introduced, which is indeed an inalienable part of a capitalist system, the causality moves in the opposite direction (Sen [1970]). It's the investment which determines the *actual* output O, thereby, actual savings, which are more likely to be different from its full capacity levels O^*. This creates a difference between the actual and the potential rates of growth and the economy ends up functioning below its full capacity frontier with the capacity utilisation given by O/O^*.

is a capital expenditure, it also creates capacity simultaneously. So, unlike the usual government consumption expenditure G_c, this would show up on the investment side. I_g, accordingly represents government financed capital expenditure whereas private investment is given by I_p and their sum is the total investment I in the economy. Given that this policy may have implications for trade balance of the economy owing to the import intensity of greener technologies, we discuss an open economy version with fixed exchange rates (for simplicity). Exports X are determined in that case exogenously by external demand. Imports M are a constant proportion μ of the total domestic output. We will discuss the changes in import intensity as a comparative static exercise. c is the Keynesian average propensity to consume, t is the tax rate, which is indirect in nature i.e. we abstract away from direct taxes for simplicity of representation.

$$\begin{aligned} O &= cO + I + \bar{G}_c - t.O + \bar{X} - \mu O \\ &= \frac{I_p + I_g + \bar{G}_c + \bar{X}}{s + t + \mu}; \qquad I \equiv I_p + I_g \\ &= \tau(I_p + I_g + \bar{G}_c + \bar{X}); \qquad \tau = \frac{1}{s + t + \mu} > 1 \end{aligned} \tag{1}$$

It can be seen from equation 1, an increase in green growth investment, ceteris paribus, increases the output of the economy in the short run provided the latter does not reach its full capacity level ahead of the multiplier (τ) process playing itself out. An increase in import intensity partially nullifies this effect since it dampens the multiplier because a part of the demand 'leaks out' of the economy.

The private sector incurs a part of this green expenditure, so, it shows up in their investment function. Moreover, private investment also rises as a result of this increase in demand for the output. So, the long run effect can be captured by making private investment a positive function of output and an autonomous factor given by γ_0, which increases as a result of increased green expenditure by the private corporate sector.

$$I_p = \gamma_0 + \gamma_u \cdot O; \qquad \gamma_0, \gamma_u > 0 \tag{2}$$

The second part of this function represents the *crowding in* effect of the increased government expenditure[2]. Substituting for output from equation 1, we can get a long run equilibrium in the following form.

[2] It can be noticed that the crowding out effect is missing here. The reason for that has been discussed above. Had there been a crowding out channel, it can be incorporated by introducing an interest rate term.

$$(1-\tau\gamma_u)I_p = \gamma_0 + \tau\gamma_u(I_g + \bar{A}); \quad \bar{A} = \bar{G}_c + \bar{X}$$
$$I^* = \frac{\gamma_0 + I_g + \tau\gamma_u\bar{A}}{1-\tau\gamma_u} \tag{3}$$

As is assumed in the Kaleckian models of this variety, the Keynesian stability condition holds, i.e. the savings function is more responsive than the investment function with respect to output. So, the denominator of the equilibrium investment level is positive. Dividing equation 3 by the capital stock gives us the endogenously determined rate of growth of the economy. Any increase in the fiscal expenditure I_g as well as corporate expenditure γ_0, the combination of which is 1.5% of GDP in our case, on green growth increases not just the output in the short run, it unleashes a higher growth trajectory in the long run as well. This is the exact opposite of what the mainstream green growth theory predicts [Blyth et al., 2014].

However, how does employment figure in all of this? As discussed above, it is the so-called natural rate of growth which is endogenised with the actual rate of growth driving the latter. Using a Kaldor-Verdoorn (KV) kind of a growth of labour productivity, which is the function of the growth rate itself, we can say that the rate of growth of employment (hence of unemployment) would be given by the difference between the actual rate of growth and the KV growth of labour productivity.

$$n = g - m(g)$$
$$\frac{dn}{dg} = 1 - m' \tag{4}$$

Whether the rate of growth of employment will rise as a result of higher growth will depend on whether labour productivity rises slower than the rate of growth. What we show below is that being more labour intensive, green growth expenditure generates higher employment growth in the economy. Regarding equation 4, m' of green technologies is lower than that of the fossil fuel based technologies.

Since this comes across as low labour productivity path, a word of caution is required. A lower labour productivity growth does *not* mean a lower growth path because, as discussed above, it is not the productivity which determines the rate of growth but the other way around. Since the rate of growth is determined endogenously (through demand) as depicted in equation 3, the role of labour productivity is only in determining the rate of growth of employment.

As for the carbon emissions resulting from this process, let's start with the proposition that there are two forms of energy programs available: fossil fuel-based E_f (with proportion α) and green energy E_g, with carbon emissions per unit given by c and zero respectively. Let's say the technologically given output-energy ratio is ϵ, then carbon emission C per unit of output in an economy can be calculated as follows,

$$
\begin{aligned}
O^* &= \epsilon \cdot (E_f + E_g) \\
\frac{C}{O^*} &= \frac{cE_f}{O^*} = \frac{c\alpha}{\epsilon}
\end{aligned}
\tag{5}
$$

There are three ways in which the carbon intensity of an economy can be brought down: (a) moving towards fossil fuels with lower carbon emitting properties (a fall in c); (b) increasing the efficiency of energy usage, which is quite low for the India (a rise in ϵ); (c) increased investment in greener forms of energy so that the dependence on fossil fuels declines (fall in α). We look at these three possibilities below followed by a discussion on employment generating capacity of this programme.

3 Policy Proposal

3.1 Fiscal Proposal and Controlling Emissions

A detailed proposal on decreasing the dependence on fossil fuels (decreasing α), or within the fossil fuels moving towards low emission sources (decreasing c) and increasing the efficiency of energy usage (increasing ϵ) for India has been presented in Pollin and Chakraborty [2015]. We present here some of the salient features of that proposal:

1. Raise the economy's level of energy efficiency through the operations of buildings, industry and transportation systems.
2. Among fossil fuel energy sources, increase the proportion of natural gas consumption relative to coal, since carbon emissions from burning natural gas are about one-half those from coal.
3. Invest in the development and commercialisation of some combination of the following technologies:
   (a) Clean renewables, including solar, wind, hydro, geothermal and low-emissions bioenergy;
   (b) Nuclear power;

(c) Carbon Capture and Sequestration (CCS) processes in generating coal, oil, and natural gas-powered energy.

Of these three, the primary focus should be on 1, and 3 (a) above as Pollin et al. [2015], Pollin [2015] have argued. Declining costs of production of clean renewables and, hence, favourable prices are one of the principal reasons for why the transition from non-renewable to these is not altogether unrealistic even in the short run. In fact, the reliance on solar energy in the rural areas in India is on a rise ever since the solar panels have become relatively inexpensive. Pollin and Chakraborty [2015] have estimated that the costs of generating electricity through clean renewables in India will be 25% lower than those in the US, which is approximately $200 billion per Q-BTU of capacity. Based on this, they have calculated the level of investment necessary to ensure a significant shift in the energy mix of India.

For raising energy efficiency, on the other hand, Pollin and Chakraborty [2015] have assumed a conservative average figure for India of $11 billion per Q-BTU of savings. They have further argued that the "rebound effects", i.e. increase in usage of energy on account of a fall in its cost, will cancel out across different usages and in activities where it does not, carbon tax/cap can be used.

Based on these estimates to fundamentally change the energy mix as well as increasing efficiency of existing sources of energy usage in India, Pollin and Chakraborty [2015] show that an additional 1.5% of the GDP (to the existing 0.5% being spent currently on green energy) is required assuming the Indian economy grows at an average of 6% over the next two decades. This includes developing the infrastructure required to make these sources of energy accessible to those it does not reach at the present moment. For this paper, we borrow this figure for estimations made below.

3.2 Infrastructure Development for the Program

So far we have not discussed the actual implementation of this policy except in terms of how to finance it.

Since we are considering a combination of renewable and non-renewable source-based energy generation, we discuss the infrastructure requirements for each of them. As far as renewables are concerned, following are the sources: solar, small hydroelectric, wind, biomass, geothermal and tidal energy. Sukhatme [2012], among others, has estimated the renewable energy potential untapped in India so far for each of these sources. Gradually the role of the non-renewables would decline, but until such time that renewables are self-sufficient, the role of non-renewables will be significant. Let us first discuss the case of renewables and the untapped potential for India followed by a discussion on expanding the current power infrastructure.

For solar power, Sukhatme [2012] estimates that if 10% of the barren land is used, it can potentially generate 5.4 quads of electricity per year. In this context, he also discusses the role of the decentralised usage of rooftop photovoltaic (PV) sources, which while contributing marginally to the national electricity generation can significantly contribute to the domestic usage of electricity for a majority of the population. For hydroelectric power generation, if 60% of the potential is utilised, about 1.1 quads can be produced per year spread across large and small plants. In the case of wind energy, he estimates that if a reasonable 40% of the total potential wind energy is tapped, then 4.8 quads can be produced per year. The other sources do not contribute a significant amount to total energy generation. Based on these estimates, he shows that the median potential energy generation through renewable resources under reasonable assumptions is 11.7 quads per year.

The smart grids can be so designed that the electricity generated through non-renewables kicks in only after the renewables are exhausted during a day. This might vary from day to day depending on weather conditions, for eg. lack of wind, an overcast day but since we are taking into account the backup being provided by non-renewables (at least up to that stage when technology and infrastructure is developed enough to meet the entire demand through renewables alone), delivery of electricity round the clock should not be a problem.

As a result of this policy, the carbon footprint of the Indian economy will *decreased by half* in per capita terms from what the IEA predicts over the next two decades. Pollin and Chakraborty [2015] show that the per capita emissions will fall to 1.5 metric tonnes as opposed to 3.1 metric tonnes that the IEA predicts under the current policy scenario (0.6% of GDP continues to be spent).

Table 1: Cost Assumptions and Impact of the Clean Renewable Energy Program

Cost Assumptions of our Model		
• 20-year investment period • 3-year delay in Implementing program • 17-year spending cycle		
	Clean Renewable Energy	Energy Efficiency
(1) Cost Assumptions	$200 billion per Q-BTU of capacity	$11 billion per Q-BTU of energy savings
(2) Annual Spending Levels	$40 billion per year (=1% of midrange GDP)	$20 billion per year (=0.5% of midrange GDP)
(3) Total Spending	$680 billion	$340 billion
(4) Total Capacity Expansion or Energy Savings	3.4 Q-BTUs of new capacity	$30.9 Q-BTUs of energy savings
Impact of Our Clean Energy Program Compared to IEA		
	IEA's 2035 Current Policies Scenario	20-year Clean Energy Investment Scenario
(5) Total energy consumption	67.7Q-BTUs	36.8Q-BTUs
(6) Total clean renewable energy supply	1.7 Q-BTUs	5.1Q-BTUs
(7) Total nuclear power supply	1.7 Q-BTUs	0 Q-BTUs
(8) Total fossil fuels + high emissions renewable	64.6 Q-BTUs	31.7 Q-BTUs
(9) Total CO_2 emissions (metric tonnes)	4.7 billion tonnes	2.2 billion tonnes (based on 70 million tonnes average emissions per Q-BTU of fossil fuels)
(9) Total CO_2 emissions per capita (metric tonnes)	3.1 tonnes	1.5 tonnes (based on 1.5 billion population)

Source: Authors calculations (see Pollin and Chakraborty [2015])

3.3 Employment: Green Job-creating Growth

The additional spending of 1.5% of the GDP on clean energy programme, over and above the current 0.6% of the GDP, will create additional jobs in the Indian economy. In fact, it generates positive *net* employment in the clean energy sector, even after we take into full account the job losses that will result due to the contraction in India's demand for fossil fuel energy. On this aspect of our policy, readers can refer to an earlier study (Pollin and Chakraborty [2015]), where it is shown that the green growth policy does not stall the employment rate. Instead, it has high employment multipliers on account of higher labour intensities of the green energy processes in comparison to the fossil fuel industry.

The Indian economy is already suffering from high levels of unemployment. Any respite in this area will benefit the poorer sections of the society, which on its own makes green growth inclusive. The previous estimates of Pollin and Chakraborty [2015] show that the total amount of direct plus indirect jobs generated through the clean energy investment project at 1.5% of GDP would be around 12 million jobs. It is about 2.5% of the overall Indian labour force of 488 million people as of 2013. Overall, the study finds that the *net* gain in employment through shifting funds out of the fossil fuel industries and into the clean energy at the level of 1.5% of India's GDP would be around 6.3 million jobs, which is approximately 1.3% of the country's 2013 workforce. It is important to state here that although the impact of clean energy investments would be strongly positive in terms of employment, its overall scope would be modest compared to the aggregate employment level in India.

Another important issue concerning the quality of jobs created through investments in the clean energy programme in India has been addressed in this study. In this paper, we build on Pollin and Chakraborty [2015] by estimating the gender, region, caste, skill and sectoral composition (formal vs informal) of the employment generated within the green energy sector. This is particularly important in the Indian case as the recent growth experience has shown that it not only failed to create enough jobs but also the jobs that have been created are skewed in terms of gender and region (Rawal and Saha [2015]). Rawal and Saha [2015] show a sharp decline in female workforce participation rate from 41% in 1999-2000 to 32% in 2011-12, with the decline being sharper in the rural areas (48% in 1999-2000 to 37% in 2011-12). The authors attribute this fall primarily to the massive contraction of employment opportunities in agriculture. Since a significant chunk of the expenses for the clean, renewable energy programme is spent for rural electrification and also for the development of the rural agricultural sector to produce clean bio-energy, it will help in addressing to some extent the problems related to the recent job trajectory in India.

4 Methodology and Data

4.1 Methodology

The methodology used in the paper is similar to the existing literature. We employ the Input-Output technique to estimate the job numbers generated through investments in the clean energy program. It is static in nature i.e. it does not take into account the changes in employment elasticities that might result from technological innovations in the future. The best case scenario is projecting employment generating capacities of different sectors based on their current elasticities. In that sense, these could overstate the case since technological innovations are more likely to increase labour productivities within a given sector. However, it is safe to assume that the *relative* elasticities across the sectors are more likely to stay similar to what they are at the moment. Since it is difficult to estimate what the labour productivities in the future are going to be like, we take the current structure of production as given and extrapolate it in the future (discussed in details in the penultimate section).

One of the limitations of this methodology, which is a limitation for any work based on the IO methodology, is that it does not take into account the changes in the production structure such a capital expenditure will entail in the future and to that effect is a static analysis in nature. The alternative to that is comparative general equilibrium modelling, which requires demand and supply elasticities to be taken into account to present a dynamic picture but it has its limitations along with the issue of the unreliability of these elasticities.[3] At the end of the day, it is always better to tell a story in as simple a term as possible because it is not about the exact numbers as they will pan out but more about the relative trends in different scenarios.

4.1.1 Employment Multipliers

A detailed methodology of calculating the employment multipliers as a result of the clean energy policy has been discussed in Pollin et al. [2015] and Pollin and Chakraborty [2015]. Our estimates on employment generation

[3]For a detailed discussion on the advantages and disadvantages of this methodology, see (Pollin et al. [2015],pp.123-144)

draw directly from the Input-Output (I/O) tables and the employment and unemployment surveys of NSS for India.

We take into account the direct and indirect content of one commodity in a unit of another commodity through the I/O table. The elements a_{ij} of the Leontief inverse matrix gives us the total input of commodity i embodied in output of commodity j. We match the NSS sectors with that of the I/O sectors to get the employment-output ratios (measured in employment per million dollar value of the gross output of an industry) for each of the I/O sectors.[4] Multiplying the Leontief inverse matrix with the employment-output ratios calculated thus gives us the employment matrix (**EM**), the diagonal elements of which tell us the direct employment generated by the sector and the sum of the rest of the column elements gives us the indirect employment generated for the sector in that column.

Combining the two components of employment, which is the total sum of the columns, generates the total employment multiplier for each of the sectors per million USD spent in these sectors. The next step is to find out the employment multiplier generated as a result of the different forms of energy-related investments.

Concerning equation 5, we divide the energy policy into two categories: improving energy efficiency (ϵ) and expenditure in renewable energy E_g. As opposed to that, the employment generated in the fossil fuels F industry is taken as a benchmark against which the green energy programme is being measured. Within this division, the first is sub-divided into weatherisation, industrial energy efficiency, smart grids & grid upgrade and public transportation; the second is divided into bioenergy, solar, wind, geothermal and small hydro. The fossil fuel is divided into coal and oil/gas production.[5]

Based on the employment matrix and the expenditure on each of these sub-divisional categories of energy programme, we can find the number of jobs that can be generated per million USD spent on these programmes. With the different weights for these subdivisions, we calculate the weighted-average of employment generated per million USD spent under the two categories of the energy programme. Finally, the relative weight of the two parts of the energy programme gives us the total employment generated through this green energy programme. These numbers are then compared with the fossil fuel employment generating capacity for the same amount of money spent.

[4]Table A1 in the Appendix provides all the industry-wise details of the matching principle employed.

[5]Table A2 in the Appendix provides the detailed weights of each industry used to build each of these individual energy sectors and also the weights to generate the programmes.

The composition of employment based on region, gender, caste, education, sector has been calculated based on the NSS which provides this information at the level of individual industries.

4.2 Data sources

We use the latest NSS 68th round unit level data (survey done in 2011-12), and the corresponding source for the Input-Output table is OECD database. NSS schedule 10 has been used to calculate the employment intensity of different sectors.

5 Results

5.1 International employment estimates

Before presenting our results, let us take a look at green job estimates at the global level. International experience shows that the countries which have already invested in clean energy programme, have immensely benefited in terms of employment. Over a period of more than a decade spanning 2004 to 2016, the estimated gross global renewable energy jobs increased almost eight times from 1.3 million to more than 9.8 million (IRENA [2017]). Globally, the clean energy sector is turning out to be one of the most labour intensive sectors, with favourable policy frameworks in several economies further helping in the generation of these jobs. Solar PV, for instance, creates more than twice the number of jobs per unit of electricity generation compared with coal or natural gas Blyth et al. [2014].

According to a recent report published by the EDF Climate Corps, the clean energy jobs in the United States is around 3.0 million in 2016, with the energy efficiency sector employing 70% of it (Environmental Defense Funds Climate Corps & Meister Consultants Group [2017]). It also suggests that solar and wind industries are each creating jobs at a rate 12 times faster than that of the rest of the U.S. economy. Rising automation in extraction, overcapacity, industry consolidation, regional shifts, and the substitution of coal by natural gas in the power sector are resulting in job losses in the fossil-fuel sector in some countries. Renewable energy is already contributing to job creation in many of these markets. In the specific case of the United States, solar generating capacity represents only slightly more than 1% of the total power capacity (coal at 26%). However, solar workers are already twice as numerous as those in the highly automated coal industry (Solar Foundation, 2017; USDOE, 2017a).

Even in a developing economy like China, the renewable energy sector employed 3.5 million people compared to 2.8 million working in the country's fossil fuel industry in 2016 (IRENA [2017]). The key job markets in the hydropower sector are China, India, Brazil, the Russian Federation and Viet Nam, which together account for 62% of the total. India's labour-intensive hydropower sector accounted for 16% of the jobs, followed by Brazil, the Russian Federation and Viet Nam.

It might also help to locate our proposal and its implications in the context of other estimates about employment generating capacity of green energy in India (IRENA [2017]). Up-to-date information for India is limited, making the extent and recent trends of renewable energy employment hard to determine. The closest estimate has been compiled from different sources by IRENA [2017], which shows that, in the large hydropower generation, which has the most reliable data available, employment has more than doubled from 100,000 to 240,000 between 2014 and 2016. For the rest of the renewable energy sources, employment generation has varied between 391,000 to 385,000 during the same period with the marginal decline arising in the solar heating/cooling category.

In India, utility-scale and rooftop solar installations reached 4.9 GW in 2016, and domestic project developers won more than 90% of tendered PV capacity - benefiting domestic employment. [6] For 2017, PV installations employment should continue to expand dramatically, given that an expected 8.8 GW of capacity will be added, almost double the pace of 2016 (Bridge to India [2017]). While domestic installers fared well, manufacturers continued to struggle because the cost of Indian-made modules is 10% higher than their Chinese counterparts, thereby, increase the import intensity on this count (rise of μ). The government has tried to find ways of addressing this rising import intensity through capital subsidies, interest-free loans and tax breaks, so-called Viability Gap Funding allocated through a bidding process, and a waiver of VAT and countervailing duties on domestically-produced components.[7] In the area of utility- and park-scale PV projects, the Council on Energy Environment and Water (CEEW) and the National Research Development Corporation (NRDC) project that it could create 58,000 direct jobs through 2022 (IRENA [2017]).

[6] These statistics have been cited from http://www.bridgetoindia.com/2016-great-year-indian-solar-industry-best-yet-come/ (accessed on February 22, 2018).

[7] This discussion has benefited from IRENA [2017] and Mercom Capital Group [2017] (https://mercomindia.com/mercom-exclusive-can-domestic-manufacturers-capture-larger-piece-growing-indian-solar-market/ (accessed on February 22, 2018))

5.2 Our results

The basic structure of the results for employment follows an earlier study (Pollin and Chakraborty [2015]), so the readers are referred to that for details and comparison. The findings here are comparable to the earlier study. Additionally, in this study, given the emphasis on the public transport sector, we have estimated, for the first time in case of India, the employment figures resulting from investments in the public transport system. Given the rising levels of pollution, which many in the popular press have justly called a medical emergency, it is critical for the economy to invest in a green public transport system.[8]

The results presented here are at a more disaggregated level, and the results may differ from Pollin and Chakraborty [2015] since we have used the latest NSS 68th round unit level data and the corresponding source for the Input-Output table is OECD database.[9] The total employment generated through the green energy programme is almost 2.5 times the jobs created through the same amount of investment in a fossil fuel programme. For a million US dollar investment, 197 jobs will be created in the green energy programme compared to 82 jobs in the fossil fuel industry (Table 2).

Table 2: Employment Generation from Investments in Green Energy vis-á-vis Fossil Fuel Program

	Direct	Indirect	Total
Green Energy	115.2	82.2	197.4
Energy Efficiency (33%)	76.9	83.8	160.7
Renewable Energy(67%)	134.0	81.4	215.5
Fossil Fuel Program	29.8	52.6	82.4

Note: Jobs per $1 million; figures are for 2011-12
Source: Authors calculations (see text for details)

These employment figures for renewable energy vis-à-vis the fossil fuel industry should not be startling as they are in tandem with the international estimates discussed earlier.

We also report the distribution of these green jobs across different com-

[8]The importance of an expanded public transport system, especially the Indian railways, and its associated benefits has been discussed in great details in a report published by the Planning Commission (Government of India [2014]).

[9]The other reason for the aggregate figures to differ is due to the inclusion of public transport system in the calculations.

ponents of the clean energy programme in Table 3. As observed in Table 3, the renewable energy sector and the energy efficiency sector generates 216 and 161 jobs respectively per million dollars of investment. These results are again quite similar to our earlier findings (Pollin and Chakraborty [2015]). The bioenergy sector is the most labour intensive sector. We find that almost 429 jobs can be generated per million dollars of investment in this sector. In other renewable energy sectors – hydro, wind, solar and geothermal - the total employment creation ranges from 142 to 177 jobs per million dollars of investment. Within the energy efficiency programme, weatherization and building retrofits seem to be the most labour intensive sector generating around 218 jobs per million dollars, followed by the public transport sector which creates roughly around 150 jobs per million dollars of investment. The latter again brings forth the importance of the public transport sector in the Indian economy.

Table 3: Employment Creation through Spending in Alternative Energy Sectors

	Direct	Indirect	Total
Renewable Energy			
Bioenergy	375.9	53.4	429.3
Solar	67.2	85.4	152.6
Wind	56.6	85.7	142.2
Geothermal	91.1	86.0	177.1
Small Hydro	79.3	96.7	176.0
Weighted Average for Renewable	134.0	81.4	215.5
Energy Efficiency			
Weatherization	135.5	82.9	218.4
Industrial EE	56.9	92.7	149.6
Smart Grids	46.7	79.2	125.9
Public Transportation	71.8	78.4	150.2
Weighted Average for Energy Efficiency	77.7	83.3	161.0
Fossil Fuels			
Coal	35.0	56.6	91.6
Oil and Natural Gas	24.5	48.6	73.2
Weighted Average for Fossil Fuels	29.8	52.6	82.4

Note: Jobs per $1 million; figures are for 2011-12

Source: Authors calculations (see text for details)

As mentioned earlier, we have, for the first time, looked into the composition of employment to reflect on the type and quality of jobs created through investments in the green energy programme in India. To study this aspect, we looked into the gender-wise composition of jobs created in the green energy programme as compared to those in the fossil fuel industry. The job distribution in the green energy programme is more favourable towards females compared to those in the fossil fuel industries. We find that the ratio of male to female jobs in the green energy programme is 4:1 as against 7:1 in the fossil fuel industry indicating that green energy programme is more equitable regarding the gender distribution of jobs. As evident from Table 4, for every million dollars of investments, 37 jobs are created for females in the green energy programme compared to 11 jobs in the fossil fuel industry. This is in line with Baruah [2014] who argues that there is 'tremendous potential' to generate employment and other livelihood opportunities for women at all levels of the clean energy chain. Although male jobs dominate 81.1% of total employment in the green energy program, in the fossil fuel sector these jobs constitute 86.9% of the total employment. This, in general, reflects the male dominance of employment in the energy sector. The investments in a clean energy economy should be seen as an occasion to provide a whole range of new opportunities for women. Employment opportunities for women is overall worse than in the various clean energy sectors.

Table 4: Gender-wise Distribution of Jobs

	Direct	Indirect	Total
Green Energy			
Male	89.0	71.1	160.1 (81.1%)
Female	26.2	11.1	37.3 (18.9%)
Fossil Fuels			
Male	25.2	46.4	71.6 (86.9%)
Female	4.6	6.3	10.8 (13.1%)

Source: Authors' Calculation
Note:The bracketed figures show the share of jobs.

Table 5: Region-wise Distribution of Jobs

	Direct	Indirect	Total
Green Energy			
Rural	86.0	36.9	122.9 (62.3%)
Urban	29.1	45.3	74.5 (37.7%)
Fossil Fuels			
Rural	17.3	23.1	40.4 (49.0%)
Urban	12.5	29.5	42.0 (51.0%)

Source: Authors' Calculation
Note:The bracketed figures show the share of jobs.

We further decomposed the job numbers to find out the region wise distribution of employment generated through investments in the green energy programme vis-à-vis those of the fossil fuel industry. We observe that the allocation of jobs is more favourable for the rural sector in the green energy programme when compared to those of the fossil fuel industry. From Table 5, we observe that in the green energy programme, for every one job generated in the urban sector, almost two equivalent jobs are generated in the rural sector. In the case of the fossil fuel industry, that ratio is nearly 1:1. Similarly, the rural share of employment in the green energy program is 62.3%, whereas the urban share is less than even 40.0%. It shows that with investments in the clean energy program, more employment opportunities will be generated in the rural areas, which to a certain extent might solve the acute unemployment problem in these areas. However, in both the scenarios, more indirect jobs are created in the urban sector.

We extend this analysis to see how the green energy programme affects different caste groups (table 6). For the same amount of expenditure, the green energy programme generates 1.5 and 1.3 times higher jobs than fossil fuels for the STs and SCs respectively. In percentage terms, the share of the SCs and STs, who represent the most deprived sections of the Indian society, in the clean energy program is 31.6%, whereas the share of the same group in the fossil fuel sector is 23.8%. Hence, the upper castes of the Indian population has a much lower representation of 28.9% in the green energy program compared to 34.6% in the fossil fuel sector. The reason for this is that the green jobs created in rural areas have a higher proportion of the workers coming from these oppressed sections.

Table 6: Caste-wise Distribution of Jobs

	Direct	Indirect	Total
Green Energy			
ST	12.5	4.6	17.1 (8.7%)
SC	27.4	17.7	45.1 (22.9%)
OBC	47.6	30.5	78.1 (39.6%)
G	27.6	29.5	57.0 (28.9%)
Fossil Fuels			
ST	2.8	2.1	4.8 (5.8%)
SC	7.4	7.5	14.8 (18.0%)
OBC	12.1	22.2	34.3 (41.6%)
G	7.5	21.0	28.5 (34.6%)

Source: Authors' Calculation
Note: The bracketed figures show the share of jobs.
Notations: ST= Scheduled Tribes; SC= Scheduled Castes; OBC= Other Backward Castes; G= General (Upper Castes)

It is usually assumed that there might be a skill gap between the demand and supply of labour in developing countries, which might be particularly acute in newer areas of technologies, say the green sector, since the skill requirements are yet unknown. Fortunately, the skill requirement based on the current state of green technology and its impact on jobs created in the process is not a black box because most of these sectors are already in operation. We find that the skill set required in green energy are tilted towards unskilled labour (table 7). For every high skilled job created in the green energy sector, more than six unskilled jobs will be created whereas, in the fossil fuel, it creates less than four jobs. Our findings are similar to a primary survey based study done by Jairaj et al. [2017], where the authors find that 'many clean energy jobs in fields such as construction, installation, sales, and operations and maintenance will go to unskilled and semi-skilled workers—those who lack the formal training or educational background needed to secure well-paid, full-time employment.' Not surprisingly, the educational attainment levels in the clean energy sectors are relatively low, though basically not less so than in the fossil fuel sectors. In table 7, the composition of employment based on education levels shows that 36.1% jobs in the fossil fuel sector are for graduate and higher degree holders, while in the clean energy sector that proportion is only 14.0%. A distribution tilted in favour of unskilled labour in the green energy sector makes it a more inclusive growth strategy.

Table 7: Education-wise Distribution of Jobs

	Direct	Indirect	Total
Green Energy			
No Education or Below Primary	50.9	20.5	71.4 (36.2%)
School Education (including diplomas)	55.2	43.2	98.5 (49.9%)
Graduates and above	9.3	18.3	27.6 (14.0%)
Fossil Fuel			
No Education to Below Primary	37.9	14.5	52.4 (21.8%)
School Education (including diplomas)	0.5	0.2	0.7 (42.1%)
Graduates and above	12.5	5.7	18.3 (36.1%)

Source: Authors' Calculation

Note: The bracketed figures show the share of jobs.

However, the distribution of jobs across unorganized and organized sectors of the economy is skewed in favour of the former for the clean energy vis-á-vis the fossil fuel sector. From investments in the clean energy program, for every one job in the unorganized sector, only one job is created in the organized sector, whereas in the fossil fuel sector for every one job in the unorganized sector, almost six jobs are created in the organized sector. International experiences from Bangladesh show that if policies can be properly framed in the green energy program, it significantly improves the livelihoods of the poor, especially the youth and women in the unorganized sector [Islam et al., 2011]. The Indian experience shows that the jobs generated in the clean energy sector provide reliable income, healthcare benefits, employee safety policies, and training/capacity building opportunities. However, the loophole is that there is a major tendency of the employers to hire workers as contractors so that the latter is not subjected to the same labour standards as provided by the Industrial Disputes Act of 1947 [Jairaj et al., 2017]. This policy loophole needs to be immediately closed. Nonetheless, it poses a major challenge to this program and to the system as a whole. The challenge will be precisely to encourage these workplaces to become increasingly organized. A similar recommendation is also given by Jairaj et al. [2017] where the authors argue that policies and programs should be designed in ways that embed and foster community- and village-level project ownership, and also end the process of hiring workers as contractors.

Table 8: Sector-wise (Informal/Formal) Share in Jobs

	Direct	Indirect	Total
Green Energy			
Unorganized	74.5	31.9	106.5 (53.9%)
Organized	40.9	50.1	91.0 (46.1%)
Fossil Fuel			
Unorganized	5.0	7.2	12.2 (14.8%)
Organized	24.7	45.4	70.2 (85.2%)

Source: Authors' Calculation
Note: The bracketed figures show the share of jobs.

6 Total Employment Creation from the Clean Energy Program

In this section, we report the overall job numbers generated through this Indian clean energy investment programme at the level of 1.5% of GDP. However, to report these numbers we need to make two significant assumptions. Firstly, we assume that the 'domestic content' is stable as the renewable energy and energy efficiency investments expand significantly, i.e. there is no change in the proportion of the imported inputs to meet the expanding demands of renewable energy and energy efficiency sectors.[10] Secondly, we assume that only 70% of the total investment for clean energy will be spent on creating capacity and producing, refining, transporting and marketing energy. The rest 30% will be allocated to cover the financing costs of these projects. Employing these assumptions in Table 9, we estimate that the total amount of jobs created through the clean energy investment project would be about 8.3 million in Year 1. This is approximately about 1.6% of the total labour force of the Indian economy, which is around 503.8 millions as of 2015.[11] The net gains in employment over the fossil fuel industry is around 4.8 million jobs in Year 1. The net gains in employment from investments in the clean energy program vis-á-vis the fossil fuel program will be around 1.0% of India's total labour force in 2015, which is strongly positive. However, the overall scope of making a significant impact on the Indian labour market would be relatively modest.

Table 9: Overall Employment Impact of Clean Energy Program

Assumptions of our program			
• 'Domestic content' remains stable • 70% of investment for capacity creation/production/distribution • Indian labour force in 2015 = 503.8 million			
	Clean Energy	Fossil Fuel	Net Employment
Total Employment	8.3 million	3.5 million	4.8 million
Share of Total Labour Force	1.6%	0.7%	1.0%

Source: Authors' Calculation
Note: The employment figures are for Year 1 of the 20-year program.

[10]The reason why we make this assumption is that earlier studies done by Pollin and Chakraborty [2015] and Pollin et al. [2015] on India and other countries showed that declines in domestic contents don't cause any significant change in the employment figures.
[11]The data has been cited from World Development Indicators, World Bank

7 Conclusion

In this paper, we have presented a green energy policy proposal, which not only has a higher employment potential but also delivers higher growth to the economy on account of the increased fiscal expenditure that this programme entails. Regarding the composition of employment, the green energy programme is more progressive than its fossil fuel counterpart, whether we look at it through the lens of gender, region, caste or skill. Our focus has been primarily on direct and indirect jobs calculated from the current IO structure of the Indian economy. So, while we have not managed to calculate jobs generated through the multiplier effect, what the literature refers to as 'induced' jobs, we can say with some degree of certainty that the induced jobs will be even higher in the green energy programme since the green jobs created are skewed towards the poorer sections of the population who have a higher propensity to consume, thereby, have a higher demand multiplier.

In the long-run, building a clean energy economy in India, as opposed to expanding its existing fossil-fuel dominated energy system, will generate both major opportunities and challenges for the economy in terms of the employment effects. The opportunities exist since there will be an overall net gain of employment in the Indian economy with the expansion of our clean energy program. The challenges, then, will be to encourage and support these workplaces to become increasingly organized and formalized such that this expanding workforce benefits from better quality jobs, higher and stable earnings, and other employment benefits like health insurance, pension and enhanced social security. Otherwise, a significant objective of this program, which is a better livelihood for the Indian workforce, gets defeated. An organized workforce will, in turn, allow for higher productivity, higher earnings and, thereby, a more rapidly growing clean energy sector for the Indian economy.

A Appendix

Table A1: Code Matching from Input-Output Tables to NSS Categories: Employment Scenario

Industrial Categories	**IO Codes***	**NIC-2008(Sec & Div)****
Agriculture & Allied Activities	C01T05	Sec A
Mining & Quarrying	C10T14	Sec B
Food Products & Related Items	C15T16	Div 10+ Div 11+ Div 12
Textiles, Leather & Related Items	C17T19	Div 13+ Div 14+ Div 15
Wood & Related Items	C20	Div 16
Pulp, paper, & Related Items	C21T22	Div 17 + Div 18
Coke, & Related Items	C23	Div 19
Chemicals & Related Items	C24	Div 20 + Div 21
Rubber & Plastic Products	C25	Div 22
Non-metallic Mineral Products	C26	Div 23
Basic Metals	C27	Div 24
Fabricated Metal Products	C28	Div 25
Machinery & Equipment, nec	C29	Div 28
Computer & Related Items	C30T33X	Div 26
Electrical Machinery & Apparatus, nec	C31	Div 27
Motor Vehices & Related Items	C34	Div 29
Other Transport Equipments	C35	Div 30
Manufacturing nec; recycling	C36T37	Div 31+ Div 32+ Div 33
Electricity, Gas & Water Supply	C40T41	Sec D + Sec E
Construction	C45	Sec F
Wholesale & Retail Trade; Repairs	C50T52	Sec G
Hotels & Restaurants	C55	Sec I
Transport & Storage	C60T63	Sec H
Post & Tele.	C64	Sec J -Div 62
Financial intermediation	C65T67	Sec K
Real Estate Activities	C70	Sec L
Renting of Machinery & Equipment	C71	Div 77
Computer & Related Activities	C72	Div 62
R&D & Other Business Activities	C73T74	Sec M + Sec N - Div 77
Public Admin; Defense & CSS	C75	Sec O
Education	C80	Sec P
Health & Social Work	C85	Sec Q
Other Community, Social & Personal Services	C90T93	Sec R+S+T+U

*Codes are taken from OECD Input-Output Tables (IOT), 2015
**NIC Codes are in the Schedule 10 of NSS 68th round;
Sec stands for Section and Div stands for Division
Source: Compiled by authors from IO, NSS

Table A2: Weighting Assumptions for Specifying Clean Energy Sectors within India's input-Output Model

Category	**I-O Industry**	**Weights**
Bioenergy	Agriculture, Hunting, Forestry & Fishing	50.0%
	Coke, Refined Petroleum Products & Nuclear Fuel	12.5%
	Consruction	25.0%
	R&D & Other Business Activities	12.5%
Solar	Basic Metals	8.75%
	Fabricated Metals	8.75%
	Computer, Electronic & Optical Equipments	17.5%
	Electrical Machinery & Apparatus, nec	17.5%
	Construction	30.0%
	R&D & Other Business Activities	17.5%
Wind	Rubber & Plastic Products	12.0%
	Basic Metals	6.00%
	Fabricated Metals	6.00%
	Computer, Electronic & Optical Equipments	21.5%
	Electrical Machinery & Apparatus, nec	21.5%
	Construction	26.0%
	R&D & Other Business Activities	7.0%
Geothermal	Mining & Quarrying	15.0%
	Computer, Electronic & Optical Equipments	5.0%
	Electrical Machinery & Apparatus, nec	5.0%
	Construction	45.0%
	R&D & Other Business Activities	30.0%
Small Hydro	Other Non-metallic Mineral Products	18.2%
	Computer, Electronic & Optical Equipments	10.5%
	Electrical Machinery & Apparatus, nec	10.5%
	Construction	18.2%
	R&D & Other Business Activities	42.6%

Weighting Assumptions for Specifying Clean Energy Sectors within India's input-Output Model (Contd.)

Category	**I-O Industry**	**Weights**
Weatherization	Construction	100.0%
Industrial EE	Computer, Electronic & Optical Equipments	25.0%
	Electrical Machinery & Apparatus, nec	25.0%
	Construction	20.0%
	R&D & Other Business Activities	30.0%
Smart Grids	Computer, Electronic & Optical Equipments	37.5%
	Electrical Machinery & Apparatus, nec	37.5%
	Construction	25.0%
Public Transportation	Other Transport Equipments	30.0%
	Construction	20.0%
	Transport & Storage	50.0%
Coal	Mining & Quarrying	50.0%
	Chemcials & Chemical Products	50.0%
Oil & Gas	Mining & Quarrying	50.0%
	Coke, Refined Petroleum Products & Nuclear Fuel	50.0%
Renewable Energy	Bioenergy	20.0%
	Solar Energy	20.0%
	Wind Energy	20.0%
	Geothermal	20.0%
	Small Hydro	20.0%
Energy Efficiency	Weatherization	25.0%
	Industrial Energy Efficiency	25.0%
	Smart Grids & Upgrades	25.0%
	Public Transportation	25.0%
Fossil Fuel	Coal	50.0%
	Oil and Gas	25.0%

Source: Compiled by authors from IO, NSS

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