An Egalitarian Green Growth Programme for India

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This paper explores the interrelationships in India between economic growth, expanding employment opportunities and the imperative of dramatically reducing CO_2 emissions. Specifically, it shows that within a framework of economic growth, the Indian economy can both expand employment opportunities for workers, peasants and the poor while also reducing CO_2 emissions. The model assumes that India grows at an average annual rate of 6.0% over a 20-year period. Within this framework, it proposes that India increase its annual total of public and private investments in energy efficiency and clean renewable energy sources by 1.5% of gross domestic product. The paper finds that India will achieve dramatic CO_2 emissions reductions and generate major gains in employment opportunities by undertaking these clean energy investments, as opposed to maintaining the economy's existing fossil-fuel based energy infrastructure. India could accomplish these goals while also eliminating entirely its reliance on nuclear power.

An "Appendix Data Sources and Methodology for Estimates of Employment Creation through Clean Energy Investments in India" is posted on the EPW website along with this article.

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1 Introduction

What are the conditions under which economic growth produces rising well-being for working people, peasants and the poor? That, of course, is a fundamental question that economists and many other observers have grappled with intensively since the era of David Ricardo, Thomas Malthus and Karl Marx.

In recent decades, one critical issue which has become increasingly central to debates over the nature of economic growth and human well-being has been climate change. It is now a firm scientific consensus that climate change produced by emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) represents a profound and perhaps even existential ecological threat facing all regions and countries. The Intergovernmental Panel on Climate Change (IPCC), the leading international body disseminating information on the issue, has established that total GHG emissions generated by human activity will need to fall, relative to current levels, by 40% within 20 years and by 80% as of 2050 in order to control climate change. About 75% of all global GHG emissions are CO_2 emissions produced through burning fossil fuels—oil, coal and natural gas—to produce energy. As such, any programme aimed at achieving the overall IPCC greenhouse emissions reduction targets is, necessarily, also a programme to dramatically contract, if not eliminate altogether, the CO_2 emissions generated through burning fossil fuels as an energy source.

The purpose of this paper is to explore the interrelationships between economic growth, expanding employment opportunities and the imperative of dramatically reducing CO_2 emissions, as these issues play out in the case of India. Specifically, we ask: is it possible to advance an economic policy framework through which economic growth in India proceeds along a healthy long-term trajectory, and this growth trend generates both expanding job opportunities while also dramatically reducing CO_2 emissions? In other words, for the case of India, is it possible, within a framework of economic growth, to develop a unified programme that can both increase well-being for workers, peasants and the poor through expanding employment opportunities while contributing significantly towards the global project of controlling climate change?

If the answer to this question is "no," then that would leave us with two alternatives to consider. One is that India would need to face up to managing the painful trade-offs between economic growth and climate stabilisation. The other is that India would need to develop a zero-growth agenda which, consistent with the arguments of "de-growth" proponents, could deliver increased well-being for workers, peasants, and the poor while also dramatically reducing GHG emissions.[1]

However, the findings we present in this study enable us, rather, to answer this question in the affirmative. That is, we advance here a unified programme which is capable of achieving both dramatic CO_2 emissions reductions and expanding employment opportunities throughout India. We can summarise our research approach and findings simply. We consider a healthy growth trend for India over a 20-year period, specifically that India experiences an average annual growth rate of 6.0% over this 20-year period.[2] Within this 20-year growth trend, we propose that India increases its total of public and private investments in energy efficiency and clean renewable energy sources by 1.5% of gross domestic product (GDP) above its current trend rate, which was probably about 0.6% of GDP as of 2011–12.[3] That would bring total clean energy investments to about 2% of GDP in total. These clean renewable sources include solar, wind, geothermal, and small-scale hydropower, as well as low-emissions bioenergy sources. They exclude traditional wood burning, corn ethanol and other high-emissions bioenergy sources, as well as large-scale hydro projects. Energy efficiency investments would span across all four major areas of energy usage in India—that is residences, commercial buildings, transportation systems and industrial production. We deliberately work with relatively high-end estimates of the average costs of making these energy efficient and clean renewable investments.

Why should investments in clean renewables increase by 1.5% of GDP over the current trend, as opposed to some other benchmark figures? We work with this figure as a benchmark because policymakers and a wide range of analysts throughout both the advanced and developing world consistently propose clean energy/emissions reduction policy frameworks ranging between 1% and 2% of their country's GDP. Our approach for India therefore builds from such perspectives.[4]

Working from this starting point, we find that India could indeed achieve dramatic CO_2 emissions reductions while also generating major gains in employment opportunities through undertaking these clean energy investments as opposed to maintaining the economy's existing fossil-fuel-based energy infrastructure. Moreover, India could accomplish these goals while also eliminating entirely its reliance on nuclear power. Overall then, we show that it is realistic to anticipate that an egalitarian green growth programme for India is capable of making major contributions to the global project of controlling climate change while also generating millions of new job opportunities throughout the Indian economy.

2 Energy and Emissions: Indian and Global Perspectives

As of 2010, total world greenhouse emissions amounted to about 45 billion metric tonnes. In order to control climate change, the IPCC estimates that total emissions will need to fall by about 40% within 20 years, to 27 billion tonnes, and by 80% by 2050, to about 9 billion tonnes.

Of the 45 billion tonnes of total GHG emissions, about 82% are generated by energy-based sources. This includes about 32 billion tonnes of CO_2 emissions from energy sources, equalling about 75% of total GHG emissions.[5]

We can obtain valuable perspective on the magnitude of the challenges ahead by considering the CO_2 emissions level projections for 2035 by the International Energy Agency (IEA), which publishes an annual *World Energy Outlook*. As with previous editions, the 2014 edition of the *Outlook* provides projections under three scenarios: a "Current Policies" reference case; a "New Policies" case and a "450"/Low Carbon case. The IEA describes its Current Policies case, for India and all other countries and regions, as being based on the implementation of the government policies and measures that had been enacted by mid-2014. The New Policies case, by contrast, takes into account "broad policy commitments and plans that have already been implemented to address energy-related challenges as well as those that have been announced…." But this New Policies case also "assumes only cautious implementation of current commitments and plans." The IEA describes its 450/Low Carbon case as setting out "an energy pathway that is consistent with a 50% chance of meeting the goal of limiting the increase in average global temperature to 2°C compared with pre-industrial levels" (IEA 2014: 687). That is, the IEA believes that its 450/Low Carbon case provides a 50% chance for the world to control climate change.[6]

Under the IEA's 2035 Current Policies case, global emissions are at 43.4 billion tonnes, which is more than twice as high as the IPCC's 20 billion target level as of 2035. The situation is only modestly improved in the IEA's New Policies case, in which they project 2035 CO_2 emissions to total 37.2 billion tonnes. Even under the 450/Low Carbon case, the IEA still projects global emissions to be 22.4 billion tonnes. Of course, this is a dramatic improvement relative to the other two cases. But it is still 11% higher than the 20 billion tonnes target. It is critical to underscore, moreover, that the IEA describes the 450/Low Carbon case as offering only a 50 probability for success for the world to succeed in stabilising the climate. It cannot be a satisfactory situation when, even under the most aggressive policy framework for controlling climate change modelled by the IEA, we still face only a 50% chance of achieving success.

Total Energy Consumption and Carbon Emissions

For framing our analysis, it will be useful to situate the levels of energy consumption and CO_2 emissions for India within a global perspective. Table 1 presents some basic figures for this purpose. As Table 1 shows, as of 2012, total global energy

Table 1: Energy Consumption and CO_2 Emissions Levels for World, China, United States and India, 2012

	Energy Consumption		CO_2 Emissions	
	Total Primary Energy Consumption (Q-BTUs)	Per Capita Energy Consumption (Millions BTUs)	Total CO_2 Emissions (Billions of Metric Tonnes)	Per Capita CO_2 Emissions (Metric Tonnes)
World	529.8	74.0	31.6	4.5
China	115.3	85.4	8.2	6.0
United States	84.7	269.8	5.0	16.1
India	31.2	25.0	2.0	1.6

Sources: IEA (2014). Figures vary substantially from those reported in US Energy Information Administration, "International Energy Statistics," and World Bank (2014), World Development Indicators. We use the IEA figures throughout to maintain consistency.

consumption amounted to about 530 quadrillion British thermal units (Q-BTUs) from all energy sources—including fossil fuels, all renewable sources and nuclear power. This is while total CO_2 emissions were at 31.6 billion tonnes. On a per capita basis, global energy consumption averaged 74 million BTUs in 2012, and average per capita global emissions were at 4.5 metric tonnes.

The two leading countries in terms of both energy consumption and CO_2 emissions are China and the United States (US). But as important as the US and China are to grasping the overall global climate change challenge, they still, in combination, contribute well less than half to the overall level of global CO_2 emissions. This means that we must be at least equally concerned to develop policies that apply to all other countries. The case of India is especially significant within a global emissions reduction programme, given that the country presently accounts for 17.5% of the world's population and that it has been on a rapid economic growth trajectory for most of the past two decades. Over the next 20 years, most analysts anticipate India's share of global population to at least remain at its current percentage while its economic growth trend remains strong.

As of 2012, as we see in Table 1, India's total energy consumption was at 31.2 Q-BTUs, 5.9% of the global total, while its CO_2 emissions, at 2.0 billion tonnes, was about 5.2% of the global total. On a per capita basis, India's shares are much lower, obviously reflecting the fact that India is still at a relatively low level of average per capita GDP. Thus, its per capita energy consumption was at 25.0 million-BTUs in 2012. This is only 30% of the average level for both China and the overall global economy, and only 9% of the US figure. That is, the average resident of the US consumed nearly 11 times more energy than the average resident of India in 2010. The proportions are similar with respect to CO_2 emissions. At 1.6 tonnes, per capita emissions in India equalled only 36% of the global average and 10% of the US figure.

The per capita emissions figures in Table 1 provide an important metric for clarifying the challenge of achieving the IPCC's intermediate emissions reduction target. That is, we can express the IPCC's 20-year emissions reduction target in terms of this per capita measure, within the framework of reducing the absolute level of carbon emissions by 40%, to around 20 billion tonnes. With global population expected to rise to about 8.7 billion in 2035, this means that carbon emissions will need to fall from its current level of 4.5 tonnes to 2.3 tonnes per capita within 20 years.

The challenge of achieving this decline becomes especially sharp when we also consider the current pattern in the relationship between per capita GDP levels and emissions. Not surprisingly, there is a strong direct correlation between per capita GDP and per capita emissions levels. Table 2 shows this clearly. As we see, of the total of 60 countries in which emissions per capita are currently at or below 2.3 tonnes—the average level for all countries that the world needs to reach within 20 years—average GDP per capita was $1,768. Further, of the 74 countries in which per capita emissions were at or below the current world average of 4.5 tonnes, average GDP per capita was $3,058. By contrast, of the 13 countries in which per capita emissions were above 10 tonnes, average GDP per capita was $33,700.

Table 2: World Income-Level Groupings and CO_2 Emissions Levels, 2010

	Number of Countries	Average Per Capita GDP
Countries with per capita CO_2 emissions at or below 2.3 metric tonnes	60	$1,768
Countries with per capita CO_2 emissions at or below 4.5 metric tonnes	74	$3,058
Countries with per capita CO_2 emissions above 10.0 metric tonnes	13	$33,700

Source: World Bank (2014), World Development Indicators, Tables 1.1, 3.8, 3.9 and authors' calculations.

From these figures, it is clear that the responsibility for bringing the global average per capita emissions level down from 4.5 to 2.3 million tonnes (mt) within 20 years must start with the 13 countries whose emissions levels are over 10.0 mt, and especially the US, in which both per capita and absolute emissions levels are at the highest global levels. Correspondingly, the 60 countries, including India, in which per capita emissions are already at or below 2.4 mt cannot be asked to face the same demands in terms of emissions reductions.

At the same time, if emerging economies with present per capita emissions levels below 2.4 mt proceed along a rapid economic growth trend that is powered primarily by a comparable growth of fossil fuel consumption, the chance of achieving the IPCC target will be close to zero. This is especially true for India among this group of low per capita emissions countries, given its substantial share of the global population. Thus, the challenge for India specifically is to proceed with a healthy GDP growth trajectory while still managing to stabilise or even lower its per capita emissions level. How India can achieve this goal is the topic on which we now focus.

Options for Reducing Carbon Emissions

Notwithstanding the wide differences in levels of economic development across the globe, the fact remains that there are only a limited number of ways in which any country, regardless of its level of development, can control its CO_2 emissions while still consuming energy resources to an extent sufficient to support rising average living standards. These are (listed in no particular order of significance):

(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.

We have argued at length elsewhere (Pollin 2015; Pollin et al 2015) that, for all countries at all levels of development, including India, there are only two truly viable options among these possibilities. These are: (1) Investments to raise energy efficiency levels; and (2) Investments to expand capacity in clean renewables. The reasoning behind these choices becomes clear through comparing the relative prospects for non-renewable energy sources versus those for clean renewable and efficiency investments, both in general, and with respect to India, in particular.

3 Prospects for Non-Renewable Energy Sources

By far, the major source of global CO_2 emissions is burning oil, coal and natural gas to produce energy. Emissions do vary significantly between these three sources. Coal emissions, at roughly 100 million tonnes per Q-BTU, are, respectively, about 50% higher than those for oil and 80% higher than with natural gas. Oil emissions are therefore also about 20% higher than those for natural gas. Yet, despite the fact that oil, and still more, natural gas, are cleaner-burning than coal, there are still no scenarios through which the IPCC's 20-year global emissions target is achievable if consumption levels increase over this time period through any combination of oil, coal and natural gas usage. This includes an implausible scenario in which natural gas substitutes for 100% of global coal usage.

There are still two alternative possibilities to reduce emissions levels while continuing to utilise non-renewable energy sources. Nuclear power is the first such option, since it generates electricity without producing CO_2 emissions. But nuclear power also creates major environmental and public safety concerns, which have only intensified since the March 2011 meltdown at the Fukushima Daiichi Power Plant in Japan. Similarly, CCS technologies present hazards. These technologies aim to capture emitted carbon and transport it, usually through pipelines, to subsurface geological formations, where it would be stored permanently. But such technologies have not been proven at a commercial scale. The dangers of carbon leakages from flawed transportation and storage systems would, in any case, only increase to the extent that CCS technologies are commercialised.

With India specifically, as of 2012, 75% of its energy supply was provided by non-renewables, of which only 1% came from nuclear energy. CCS technologies do not yet operate at commercial scale in India at all. It is clear that for India to move onto a clean energy growth trajectory will therefore entail a massive shift away from oil, coal and natural gas as the country's basic energy sources.

At present, India relies mostly on imports to supply both oil and natural gas. A shift away from these energy sources should therefore enable India to become less import-dependent in general. The situation is different with coal. India has the fifth largest coal reserves in the world, and is the world's third largest coal producer. At the same time, in recent years, India has had to import coal to meet high demand in both the iron and steel industries, and for generating electricity. As of 2011, coal imports had reached 11% of total demand, and this figure would almost certainly rise further if India's growth path continued to rely on coal as its primary energy source. Thus, here again, a shift away from coal consumption through a clean energy development project will enable India to reduce its demand for imports.[7]

4 Prospects for Clean Renewables

It will be necessary to create a rapidly expanding and successful clean renewable energy sector on a global scale in order to achieve both the IPCC's 20-year emissions reduction target as well as its target for 2050. In fact, it is realistic to allow that renewables could provide in the range of 30% of all global energy supplies within 20 years. The main driver here is that the trajectory for prices and costs for renewables is becoming increasingly favourable. Under a wide range of conditions—if not yet under all circumstances—renewable energy from most sources will be at cost parity with non-renewables within the next 5–10 years.

Thus, according to the 2013 Report of the International Renewable Energy Agency (IRENA), the costs throughout the globe of generating electricity through onshore wind, hydropower, geothermal, and most forms of biomass energy were, as of 2012, already comparable to those for fossil fuels within the Organisation for Economic Co-operation and Development (OECD), which ranged at about 7–12 cents per kilowatt hour.

With respect to India specifically, recent assessments are consistently quite favourable as to the prospects for renewables. Thus, the 2013–14 *Annual Report* of India's Ministry of New and Renewable Energy finds that

> The renewable energy sector landscape in India has during the last four years witnessed tremendous changes in the policy framework with accelerated and ambitious plans to increase the contribution of solar energy. For the first time perhaps, not only is there the perception that renewable energy can play a significant role as also there is confidence in the technologies and capacity to do so (2013: 19).

The increasing technological potential for renewable energy in India was also strongly supported in an important 2012 paper by S P Sukhatme, "Can India's Future Needs of Electricity be Met by Renewable Energy Source? A Revised Assessment." The "revised assessment" to which Sukhatme is referring is that, contrary to earlier views, it is now widely accepted that renewable energy has the potential to meet all of India's future demand for electricity, assuming that the country also undertakes major investments in energy conservation and efficiency.

Despite these highly optimistic assessments for renewables in India, there are also major areas of concern. The first is that, as mentioned above, some bioenergy sources, including traditional solid biomass and waste, wood-burning, in particular, offer no improvement on emissions relative to burning fossil fuels.[8] This issue is particularly significant in the case of India, in which solid biomass and waste account for fully 23% of all energy consumption, with rural areas, in particular, relying on these energy sources for cooking, heating and lighting because they lack access to other energy supplies.

A second major concern is that a rapid expansion of bioenergy production could raise food prices. This is because the production of many forms of bioenergy requires agricultural products as raw materials. Large increases in the production of bioenergy will therefore require increasing overall agricultural production and shifting resources, at least to some extent, towards meeting demand from the non-food bioenergy market. If food prices were to rise as a result, the most adverse impacts would be on the living standards for low-income people in developing countries, for whom food purchases typically constitute between 50% and 70% of their total consumption basket.

However, it is not clear that the expansion of bioenergy production has significantly influenced global food prices to date, or would necessarily do so in the future. Average global food prices did rise sharply over the past decade, especially during the huge food price bubble between 2004 and 2008. However, the dominant factor here was the rise in speculative activity on the commodities futures markets, not the expanded demand for agricultural output generated by bioenergy production (Ghosh, Heintz and Pollin 2012; Pradhananga 2014).

It is also the case that the development of a clean bioenergy sector could potentially contribute towards both reducing the threat of climate change and addressing concerns over food security. This is true first because droughts, floods and extreme weather events more generally have also been major sources of rising food prices (Nelson and Olofinbiyi 2012; Commission on Sustainable Agriculture and Climate Change 2012). In addition, any possible impacts of expanding bioenergy production on food prices can be minimised through encouraging investments that both raise agricultural productivity and expand the use of non-food agricultural resources, such as switchgrass, corn stover, and waste grease, as bioenergy raw materials.[9]

We confront similarly challenging issues with hydropower, especially in considering large-scale hydro projects throughout India. It has long been documented that the construction and subsequent operation of large-scale dams in India have had serious negative impacts on the nearby communities and environment. This has emerged most recently in struggles over the construction of what would be the largest project in India, the Lower Subansiri Dam. Construction of the project has been stalled for three years because of "massive protests in Assam by local people and the farmers' organisation Krishak Mukti Sangram Samiti." The South Asia Network on Dams, Rivers and People (SANDRP) has characterised this dam project as "another chapter of environmental subversion in Northeast India."[10]

Small-scale hydro projects are widely seen as a much more ecologically viable alternative to mega-scale dam developments, in India and elsewhere. Small-scale hydro projects operate in rivers and streams without requiring the construction of a dam or reservoir. These projects rather utilise a conduit running parallel to the flow of the stream or river, which carries the water to a turbine placed within the river/stream. Once the water flows through the turbine to generate electricity, it is then returned to the river or stream's natural flow. As summarised by Kosnik, "Such small generation facilities have very few of the negative riverine impacts to which larger, more conventional hydropower plants have been prone to" (2010: 5512). A recent World Bank assessment of renewable energy potential in India concludes that small-scale hydro is a "very attractive" but still a "largely untapped" resource for India, especially in Himachal Pradesh, Jammu and Kashmir, and Uttarakhand, which, according to this study, "have 65% of India's small hydropower resource and among the lowest generation costs" (Sargsyan et al 2010: 18).

Despite the much more favourable prospects for small-scale hydro, a 2014 study by Baker on all 49 completed projects in Himachal Pradesh still found that the vast majority of these projects "have generated unmitigated negative effects, ranging from disruptions to local irrigation systems and water-powered mills, to the undermining of fisheries-based livelihoods" (p 78). Still, Baker does not dismiss the potential opportunities for small-scale hydro in India. He rather suggests the development of alternative institutional arrangements for developing these projects, through which the needs of local communities and ecologies are at all times maintained as central to the planning process. These two alternative institutional arrangements entail leadership in the projects being assumed by either non-profit or cooperative entities, such as the Sai Engineering Foundation or the Churah Floriculture Cooperative Society (2014: 84).

Cost Estimates for Clean Renewables in India

IRENA has produced estimates of the total levelised costs of electricity generation specifically for the case of India. We show these figures in Table 3, along with comparable figures for the US. As we see in Table 3, other than with solar energy, the average levelised costs for India are lower than those for the US. These average costs are about 11% lower for large-scale hydro (we do not have figures for small-scale hydro in the US); 20% lower for onshore wind; and 60% lower for bioenergy. In addition, as discussed before, the levelised cost range for electricity generation with fossil fuel energy within the OECD countries was between 7 and 12 cents per kilowatt hour. The average figures for India are well within this range for fossil fuel electricity within the OECD.

Table 3: Estimated Levelised Costs of Electricity (LCOE) in India and the US

Figures are USD cents per kilowatt hour (kWh)

	India Estimates for 2011; in 2011 $		United States Reference Case for 2017; in Current $	
	Average	Range	Average	Range
Large-scale hydro	8	3–12	9	6–15
Small-scale hydro	5	2–13	NA	NA
Onshore wind	8	3–12	10	6–9
Bioenergy	5	1–20	12	10–14
Solar PV	23	8–37	15	9–22

Sources: IRENA (2013); US EIA (2013).

These comparative cost figures provide further support on behalf of the viability of clean renewables in India moving forward. They also provide a basis for producing a rough framework for estimating the capital costs for expanding clean renewable capacity in India. This is because we do not have direct figures on capital costs per Q-BTU of capacity for India, but we do have such figures for the US case. That is, working from data developed by the US EIA, Pollin et al (2014, Table 3.16) estimate that, as rough midpoint figures after allowing for cost reductions as renewable technologies improve between 2017 and 2035, the capital expenditures required to expand renewable capacity in the US by 1 Q-BTU would be as follows: $166 billion for clean bioenergy; $284 billion for hydro; $245 billion for wind; $417 billion for solar photovoltaic; and $226 billion for geothermal. Thus, the average cost figure in the US for these five clean renewable sources over a 20-year investment cycle would be $274 billion per Q-BTU of capacity.

For the Indian case, we assume that the average cost figures will be about 25% lower than in the US case, that is at about $200 per Q-BTU. We base this assumption on the fact that average labour costs in India are dramatically lower than those in the US. For example, the US Labor Department has most recently reported that average hourly compensation in Indian manufacturing is about 4% of the US figure—that is $1.46 per hour in India versus $35.67 in the US.[11]

It is also probable that non-labour costs will be higher in India's clean energy sectors. Nevertheless, these cost differentials for all other productive inputs in clean energy—that is materials, transportation, energy and management—are not likely to be more than 50% higher than those in the US. If we assume that those other inputs are within the range of 50% above those in the US, we can roughly estimate that average costs for expanding clean renewable capacity in India will be about $200 billion per Q-BTU. At the same time, we want to emphasise here that it is less important to try to establish what are the most reliable cost estimates than to evaluate the viability of large-scale renewable estimates when we assume these costs will be relatively high. If the actual costs of expanding renewable capacity are lower than what we have assumed, then this only strengthens our conclusion as to the viability of the project to expand clean renewables.

5 Prospects for Energy Efficiency

Significantly rising energy efficiency levels in all four major areas of energy usage—that is residences, commercial buildings, industry and transportation—offers major opportunities for all countries at all levels of development. This is why, along with investments in clean renewables, it needs to be one of the cornerstones of a global clean energy investment project.

For the case of India specifically, there are widespread opportunities at all levels of economic activity for major gains through efficiency investments. For example, the 2006 report *Integrated Energy Policy* by the Expert Committee of the Government of India's Planning Commission describes these opportunities for India as follows:

> The major areas where efficiency in energy use can make a substantial impact are mining, electricity generation, electricity transmission, electricity distribution, pumping water, industrial production and processes, transport equipment, mass transport, building design, construction, heating ventilation, and air conditioning, lighting, and household appliances (Government of India 2006: 81).

The Integrated Energy Policy report further notes that "since nearly one-third of total energy is used for domestic cooking, efficiency of the cooking process should be given a high priority, particularly since this process is currently marked by poor level of efficiency" (p 83). As such, large-scale efficiency investments targeted at improving cooking will provide major benefits for lower-income households throughout the country.

More generally, the report describes a large number of specific measures, affecting all areas of economic activity in India. The report characterises some of these as "low hanging fruit," yielding quick returns. These measures include mandating manufacturers of cooking stoves to label the stoves according to their fuel requirements and implementing time-of-day tariffs for large industrial and commercial energy consumers to flatten the daily load curves. The report also includes medium- to longer-term initiatives, such as establishing efficiency benchmarks for buildings and shifting freight traffic to railways, as well as promoting waterways, urban mass transport and fuel-efficient vehicles. The report estimates that such measures, in combination, could achieve "cost-effective saving" of "at least" 15% of current total energy consumption levels.

It is important to underscore the ways through which a more egalitarian distribution of consumption in India would interact positively with raising efficiency standards throughout the economy. As one major factor, a more egalitarian distribution would facilitate the process of lower-income households having the wherewithal to purchase more efficient cooking equipment. Similarly, large-scale investments to improve urban mass transit systems would raise energy efficiency standards in transportation while also reducing transportation costs for lower-income households.

The long-standing question with efficiency investments is, given that they will produce significant energy savings, then why have not people already taken advantage of them? The first, and simplest, answer is that they require upfront investments. This entails obtaining the necessary upfront investment funds and assuming the risks that are associated with any investment project. Such risks can be significant, especially given that the costs involved to achieve energy savings can vary widely, especially with large-scale projects. The main challenge for enabling the global energy efficiency investment market to grow rapidly is, therefore, to develop more effective systems of financing and risk-sharing.[12]

In Table 4, we show summary estimates from three sets of studies as to the upfront investment costs necessary to achieve

Table 4: Estimates of Cost Savings from Energy Efficiency Investments

Source	Regions/Countries/ Sectors Estimated	Estimated Savings in Reported Units	Estimated Savings in Q-BTUs
World Bank (2008: 29)	455 projects in 11 industrial and developing countries	$76 per tonne of oil equivalent (TOE)	$1.9 billion per Q-BTU (conversion: 1 Q-BTU= ~ 25,200 TOE)
McKinsey and Co (2010: 27)	Africa, India, West Asia, South East Asia, Eastern Europe, China	–	$11 billion per Q-BTU
United States National Academy of Sciences (2010; as summarised in Pollin et al 2014)	United States	–	~ $29 billion per Q-BTU for buildings, industry

large-scale energy efficiency savings. As we see, a 2008 World Bank study by Taylor et al puts average costs at $1.9 billion per Q-BTU of energy savings, based on a study of 455 projects in both industrial and developing economies, focusing, again, on India, Brazil and China. A second study by the McKinsey and Company business consulting firm (2010) estimates costs for a wide range of non-OECD economies at $11 billion per Q-BTU of energy savings. Considering just on the US economy, the US National Academy of Sciences (2010) estimated average costs for energy efficiency savings in the buildings and industrial sectors at about $29 billion per Q-BTU. With all of these investment cost estimates, the estimated average payback period for the investments is relatively short—in most cases, less than three years for full payback.

These alternative studies do not provide sufficiently detailed methodological discussions that would enable us to identify the main factors generating these major differences in cost estimates. But it is reasonable to conclude from these figures that there are likely to be large variations in costs at the project-by-project level. At the same time, for the purposes of our current analysis, we will need to proceed with some general rules-of-thumb for estimating the level of savings that are attainable through a typical set of efficiency projects in India. A relatively conservative approach will be to assume an average figure for India of $11 billion per Q-BTU of savings, that is the average figure estimated in the McKinsey study, which is, again, nearly six times the figure estimated by the World Bank study that focused on India, China and Brazil. As with the figures for expanding renewable energy, for our purposes, the critical issue is not that our cost estimates are accurate, but, rather, that they do not understate the magnitude of the investments necessary.

It is also possible that efficiency investments may not have their intended effect of reducing energy consumption at all. This would be due to the "rebound effect," whereby better energy efficiency encourages consumers to expand their energy-using activities. However, we conclude that any rebound effects that may emerge within the Indian economy as a by product of an economy-wide energy efficiency investment project will not be large enough to counteract their significant benefits in terms of both cost savings and emissions reductions.[13] For example, significantly improving energy efficiency in domestic cooking processes is not likely to induce significantly more cooking itself within households. At the same time, by deliberately assuming relatively high-end cost estimates for achieving one Q-BTU of energy saving, we are factoring in the prospect that rebound effects could emerge as substantial in some situations, such as heating and cooling systems for buildings. But here as well, spending on, say, air conditioning in buildings is a high-end consumer good in India. Through relatively more egalitarian consumption patterns, households would therefore spend relatively more on efficient cooking equipment and mass transit, and less on air conditioning. Nevertheless, the single most effective way to limit rebound effects is to combine efficiency investments with complementary measures to greatly expand the supply of clean renewables as well as to raise the prices of oil, coal and natural gas through either a carbon tax or carbon cap.

6 Industrial Policies and Domestic Content

Operating effective industrial policies will be critical for India to successfully expand investments in renewable energy and energy efficiency to the scale we have discussed. Effective industrial policies will also be needed to manage the unavoidable major retrenchments in India's oil, coal and natural gas sectors. Exploring the details of what would constitute an effective set of clean energy industrial policies for India is, of course, beyond the scope of this study. However, we can offer some broad ideas as to a general framework for such industrial policies.

For the purposes of this study, we are especially concerned with the question as to how much expanding clean energy investments in India can be accomplished through utilising domestic resources versus relying increasingly on imports. To the extent that India runs up against domestic productive capacity constraints while expanding its investments in energy efficiency and clean renewable energy sources, it then faces two alternatives: either scale back the clean energy investment programme or rely increasingly on imports to maintain the ambitious investment agenda. Our particular concern for this study is employment effects. That is, to what extent will changes in the domestic content of output in the relevant sectors of India's economy affect the overall job-generating prospects of its clean energy investments?[14]

How much India would be able to rely on domestic content will depend in large measure on its degree of success in implementing clean energy industrial policies. One critical feature of a successful industrial policy is the establishment of viable development banks and, more broadly, of credit allocation systems that can support the investments in new areas. The central importance of financial policies to support clean energy investments in developing countries has been explored in detail by Spratt, Griffith-Jones and Ocampo (2013). They examine the conditions under which the necessary large-scale investments in renewable energy and energy efficiency can be successfully advanced in low-income countries. The authors are particularly concerned that such investments be "inclusive," in the sense that the benefits of these investments be shared at least equally by the society's least advantaged groups. This would include expanding access to electricity, and providing clean energy, for electricity and other needs, at affordable prices. They also emphasise the need to reduce the expectations of high returns on these investments from institutional investors. They write, "Achieving growth that is both green and inclusive is inherently difficult. Doing so using private investment which requires very high returns may be impossible" (p 6).

The need for inclusive green growth financing for lower-income countries could be adopted as one of the major goals of the recently established New Development Bank (NDB), whose founding member countries include India, along with Brazil, Russia, China and South Africa. As Chandrasekhar emphasises, in order for the NDB to make a difference relative to what is already available to developing countries through the Bretton Woods institutions and similar entitles, it will need to do so "in the choice of projects within the infrastructural space, in the terms on which large loans are provided, and in the concern it shows for keeping development sustainable and inclusive" (2014: 12). Chandrasekhar himself expresses strong concerns that the NDB may not meet higher standards as a development bank than the Bretton Woods institutions. Nevertheless, as a newly-established institution, the challenge for the NDB of advancing an inclusive green growth throughout the developing world should present itself as massive opportunity.

7 Clean Energy Investments at 1.5% of GDP

Growth Trajectory and Emissions

We begin by reviewing the basic statistics indicating India's level of development and the operations of their energy system as of 2012. As we see in Table 5, per capita income as of 2012 was $1,480 (expressed in current US dollars).[15] Overall energy consumption was 31.2 Q-BTUs and overall CO_2 emissions from energy sources was 2.0 billion tonnes. On a per capita basis, India's overall energy consumption was 25.0 million BTUs, which is about one-third the global average of 75.7 million BTUs. Emissions per capita were 1.6 tonnes, which is, again roughly one-third of the 4.5 tonne global average. It is also about 40% below the targeted per capita global average emissions of 2.3 tonnes needed for achieving the 20-year global CO_2 emissions reduction target.

Table 5: Basic Energy Indicators, 2012

	India	World Figures
Per capita GDP 2012 USD	$1,480	$10,570
Total energy consumption Q-BTUs	31.2 Q-BTUs	529.8 Q-BTUs
Total CO_2 emissions from energy consumption Metric tonnes	2.0 billion tonnes	31.6 billion tonnes
Per capita energy consumption Million BTUs/person	25.0 million BTUs	74.0 million BTUs
Per capita CO_2 emissions Metric tonnes of CO_2 emissions/person	1.6 tonnes	4.5 tonnes
Emissions intensity ratio CO_2 emissions/Q-BTUs	62.6	60.0
Energy intensity ratio Q-BTUs/$1 trillion GDP	17.0	7.1

Source: IEA (2014).

India's emissions intensity ratio, at 62.6 CO_2 emissions per Q-BTU of energy, was at roughly the global average of 60.0 per Q-BTU. As such, the challenges India faces in expanding its clean renewables sector—including solar, wind, geothermal, small-scale hydro and low-emissions bioenergy—are roughly equivalent to those faced by a large proportion of other countries around the world. By contrast, India's energy intensity ratio, at 17.0 Q-BTUs per $1 trillion GDP, was 139% above the global average of 7.1. This indicates that India's energy infrastructure presently operates at a very low efficiency level, suggesting, in turn, that especially large benefits could be generated through a large-scale energy efficiency investment programme.

From 1990–2012, the Indian economy grew at a rapid average annual rate of 6.4%. Over a more recent and narrow time frame, that is between 2003 and 2012, India's annual GDP growth was significantly higher still, averaging 8.0%.[16] This sustained strong growth performance also generated rapid increases in energy consumption throughout the country. Thus, India's total energy consumption between 1990 and 2012 grew from 12.6 to 31.2 Q-BTUs. This amounts to a 4.4% average annual growth rate, meaning that the growth in India's overall energy consumption over this time period was well below its 6.4% GDP growth rate. It is therefore not surprising that the country's provisioning of energy services is still seriously underdeveloped.[17] As of 2011, 24.7% of India's population does not have access to electricity, while a substantial number of areas that are served with electricity still experience daily blackouts. In July 2012, India experienced the largest power outage ever recorded, affecting roughly 700 million people.[18] A major focus of an egalitarian green growth agenda for India would therefore be to greatly expand the delivery of electricity and other energy supplies throughout the country. This process would be greatly facilitated through expanding clean renewable energy sources, including small-scale hydro, solar, and wind power, that are capable of supplying electricity without having to rely on the construction of large-scale electrical grid systems.

Of course, we cannot know in advance what India's growth trajectory will be over the next 20 years. But we do know that if they attain anything roughly along the lines of the 1990–2012 rate of 6.4%, much less the 8.0% rate attained between 2003 and 2012, while also maintaining its existing energy infrastructure more or less intact, the result will be to generate a major increase in the country's CO_2 emissions. In Table 6, we can see what the impact would be of a 6.0% average annual growth rate under the IEA's Current Policies scenario for India through 2035, as presented in its 2014 *World Energy Outlook*. As described above, the IEA's Current Policies scenario is

Table 6: Energy Consumption and Emissions: 2012 Actuals and Alternative IEA Projections

(1)	(2) 2012 Actual	(3) 2035 IEA Current Policy Scenario
Total energy consumption (in Q-BTUs)	31.2	67.7
Energy mix:		
■ Coal	44.9%	47.7%
■ Oil	22.5%	25.4%
■ Natural gas	6.2%	9.0%
■ Nuclear	1.1%	2.5%
■ High-emissions renewables	24.6%	13.4%
■ Clean renewables	1.7%	2.5%
o Hydro	1.4%	1.3%
o All others	0.4%	1.0%
Total CO_2 emissions (billions of metric tonnes)	2.0	4.7
Emissions intensity ratio Emissions per Q-BTU (millions of metric tonnes per Q-BTU)	62.3	68.9
CO_2 emissions per capita (metric tonnes)	1.6 (population = 1.2 billion)	3.1 (population = 1.5 billion)

The IEA provides projections for the Current Policies and 450 scenarios for 2030 and 2040 only. The figures presented here for 2035 are the midpoints between the 2030 and 2040 figures. The figures from the IEA differ significantly from the other main data sources, the US Energy Information Agency's International Energy Statistics and the World Bank's World Development Indicators. For example, the International Energy Statistics reports India's total energy consumption for 2012 as 23.9 Q-BTUs, 23% below the IEA figure. We rely here on the IEA figures because they provide fuller energy consumption projections for India through 2040.
Sources: IEA (2014).

constructed around the assumption that India's energy sector policies will proceed through 2035 with only the measures that were in place as of 2014. Thus, as we see in the top row of the second column of Table 6, under the IEA's Current Policies assumptions, India's overall energy consumption rises to 67.7 Q-BTUs by 2035, a 117% increase relative to the actual 2012 level.

Moving down the rows of column 3 of Table 6, we can also see how, under the Current Policies scenario, India's energy mix would change in response to this expansion of overall energy demand. To begin with, the supply of energy from coal, the country's largest energy source as of 2012, would rise from 45 to 48% between 2012 and 2035 under the Current Policies scenario, while oil, the second largest energy source, remains nearly constant, between 22.5% in 2012 and 25.4 in 2035. The one large decline in relative share under the 2035 Current Policies scenario is the reduction of high-emissions renewables—that is primarily biomass such as wood, which falls from 24.6% to 13.4% of India's total energy supply. That 11% point loss of high-emissions renewables is replaced by the projected percentage increase in coal, along with increases in natural gas (+2.8% point), nuclear (+1.5% points) and clean renewables (+0.8% points). The gain in clean renewables would be driven by large increases in wind and solar power, albeit starting from baselines that are low (for wind) to nearly non-existent (for solar).

The impact of this large increase in energy consumption with a rising proportion supplied through burning coal—the most heavily emitting CO_2 energy source—is that India's overall emissions would increase by 133%, from 2.0 billion tonnes in 2012 to 4.7 billion tonnes in 2035 under the IEA's Current Policies scenario. Assuming India's population in 2035 is around 1.5 billion, this then also means that per capita CO_2 emissions would rise from 1.6 to 3.1 tonnes between 2012 and 2035, a rough doubling of per capita emissions. This 3.1 tonnes figure for 2035 would be 35% above the overall global target of 2.3 tonnes per capita within 20 years. As such, given India's size and significance within the global economy, the prospects would be dim for a successful worldwide emissions reduction project along the lines specified by the IPCC if India's per capita emissions were to increase by 80% within 20 years.

Emissions Reductions through Clean Energy Investments

In Table 7, we begin to present our alternative framework, in which India's growth process incorporates clean energy investments—that is investments in clean renewable energy and energy efficiency—at a rate of 1.5% of GDP annually over a full 20-year period. For the purposes of our discussion, we assume that this 1.5% of GDP is allocated with 1% of GDP funding the expansion of clean renewable production while 0.5% of GDP is channelled into energy efficiency investments.

Table 7: Clean Energy 20-Year Investment Growth Trajectory

2012 GDP	$1.9 trillion
Projected 20-year average annual GDP growth rate (from IEA 2014, p 41)	6.0%
Projected 2032 GDP (with 6.0% average annual GDP growth)	$6.1 trillion
Midrange GDP value for investment spending estimates (= (2012 GDP + 2032 GDP)/2)	$4.0 trillion
Average annual clean renewable investments (= 1% of midrange GDP)	$40 billion
Average annual energy efficiency investments (= 0.5% of midrange GDP)	$20 billion

Source: Authors' calculations.

Growth assumptions for clean energy project. For the purposes of our discussion, we are assuming that India's average annual GDP growth rate over this 20-year period is 6.0%. This is the IEA's average annual growth projection over 2012–40 for India. This GDP growth rate is, of course, well below both India's actual growth trajectory from 2003 to 2012 of 8.0% as well as the projections ranging between 8.0% and 9.5% used in at least some modelling exercises by India's Planning Board.

As Table 7 shows, with a 6.0% average annual growth rate over 20 years, this would mean that India's GDP in 20 years would be $6.1 trillion. To then estimate an average level of clean-energy investment spending over this 20-year period, we simply calculate the midrange GDP value between 2012 GDP at $1.9 billion and 2032 GDP at $6.1 trillion. That figure is $4.0 trillion. This then means that the average level of annual spending on clean energy would be 1% of $4 trillion per year for renewables, which is $40 billion, and 0.5% for energy efficiency, which is $20 billion per year.

Clean Energy Capacity and Emissions

In Table 8, we estimate the levels of capacity expansion for both clean renewables and energy efficiency, building from the cost assumptions we described in Sections 4 and 5 above. With energy efficiency investments, we work from the average cost figure provided by McKinsey and Company (2010) of $11 billion per Q-BTU of energy saving—this figure, again, is nearly six times higher than the World Bank's (2008) average cost estimate, focused on India, China, and Brazil, of $1.9 billion per Q-BTU of energy savings. With respect to an overall clean renewable investment program, we work from the assumption on average costs of $200 billion per Q-BTU of capacity that we discussed in Section 4.

Working from these average cost figures, we then generate estimates for how much new clean renewable capacity would be built or energy savings achieved within our additional set of assumptions—that is India averages 6.0% GDP growth over the full 20-year investment cycle; 1% of annual GDP is invested in clean renewable capacity; and 0.5% of annual GDP goes towards

Table 8: Cost Assumptions and Capacity Expansion for Clean Renewables and Energy Efficiency Investments

Assumptions of Model;
- 20-Year Investment Period;
- 3-Year Delay in Implementing Programme;
- 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 with 17-year spending cycle (= row 2 x 17)	$680 billion	$340 billion
(4) Total capacity expansion or energy savings through 17-year spending cycle (= row 5/row 1)	3.4 Q-BTUs of new capacity	30.9 Q-BTUs of energy savings

Source: Authors' calculations.

energy efficiency investments. We further assume that there will be a 3-year delay from the time the investment project begins until the point at which India first sees renewable energy and energy efficiency capacity expand. As such, as we see in Table 8, the accumulation of new capacity proceeds for only 17 years of the full 20-year investment cycle. Under this full set of assumptions, we see in Table 8 that total investment spending on renewables would be $680 billion over 20 years, with a 17-year spending cycle after the 3-year star-up period. Energy efficiency investments would be $340 billion, again, based on a 17-year spending cycle and a 3-year start-up period.

We then show the net effects of these investment projects in row 4 of Table 8. That is: (1) through investing 1% of GDP annually for 17 years, an average of $40 billion per year for a total of $680 billion, India would have created 3.4 Q-BTUs of clean renewable capacity; and (2) through investing 0.5% of GDP annually, $20 billion annually for 17 years for a total of $340 billion, will be able to achieve 30.9 Q-BTUs of energy savings relative to the 2035 IEA's Current Policies scenario.

Table 9 then shows the impact of this clean energy investment project for India on its overall emissions level at the end of the 20-year investment cycle, allowing, again, for an initial three year delay before actual investment spending begins.

Table 9: Impact of Clean Energy Investment Programme Relative to IEA 2035 Current Policies Scenario

(1)	(2) IEA's 2035 Current Policies Scenario	(3) 20-year Clean Energy Investment Scenario (Case 1 from Table 8, including 3-year start-up Delay)
Total energy consumption In Q-BTUs	67.7 Q-BTUs	36.8 Q-BTUs (with 30.9 Q-BTUs of energy savings)
Total clean renewable energy supply	1.7 Q-BTUs	5.1 Q-BTUs (with 3.4 Q-BTUs of additional clean renewables)
Total nuclear power supply	1.7 Q-BTUs	0 QBTUs
Total fossil fuel + high-emissions renewables	64.6 QBTUs	31.7 Q-BTUs (= 36.8 Q-BTUs in total consumption – 5.1 Q-BTUs in clean renewables)
Total CO_2 emissions Metric tonnes	4,7 billion tonnes	2.2 billion tonnes (Based on 70 million tonnes average emissions per Q-BTU for fossil fuels)
Total CO_2 emissions per capita Metric tonnes (with population = 1.5 billion)	3.1 tonnes	1.5 tonnes

Source: Authors' calculations based on calculations in Tables 7 and 8.

As we see, under the IEA's Current Policies scenario, India's total energy consumption in 2035 is, again, 67.7 Q-BTUs. Due to the 20-year energy efficiency investment project, this overall consumption level falls to 36.8 Q-BTUs, because of the 30.9 Q-BTUs of energy saving generated by the $340 billion in efficiency investments. Total clean renewable capacity in India now rises to 5.1 Q-BTUs. This includes 1.7 Q-BTUs that was built into the IEA's Current Policies scenario, plus the 3.4 Q-BTUs that would be generated through investing, above Current Policies scenario, an additional 1% of GDP per year over the 17-year period, following the initial 3-year start-up phase.

The net effect of these energy efficiency and renewable energy investments can then be seen in terms of India's residual demand for all non-renewable energy sources. We assume here, to begin with, that nuclear energy supply falls to zero, reflecting the major public safety problems associated with continuing to rely on nuclear power. As such, the demand for all fossil fuel sources and high-emissions renewables falls from 64.6 Q-BTUs under the Current Policies scenario to 31.7 Q-BTUs through the 20-year clean energy investment programme. This is a reduction of 32.9 Q-BTUs, or 51%, in the consumption of oil, coal and natural gas.

This decline in fossil fuel consumption, in turn, has a dramatic impact on India's overall CO_2 emissions within 20 years, as we see in the bottom two rows of column 3 of Table 9. We assume an average emissions level for India's fossil fuel energy mix at 70 million tons per Q-BTU.[19] Under this assumption, India's overall emissions fall from the IEA's Current Policy scenario of 4.7 to 2.2 billion tonnes, again, a 53% decline. Emissions per capita at the end of the 20-year investment cycle are then 1.5 tonnes. This 53% decline in India's per capita emissions would result within our clean energy investment programme while the economy was growing at a 6.0% average annual rate and population would have increased from 1.2 to 1.5 billion.

8 Employment Creation through Clean Energy Investments

In this section, we present the results of our estimates on employment creation through investment spending on renewable energy and energy efficiency in India. We also generate results on *net* employment creation, that is after our estimates take full account of job losses that will result through the contraction in India's demand for fossil fuel energy that, as we have seen, will accompany India's rise in energy efficiency and the expansion of clean renewable energy supply.

Our estimates draw directly from the Input–Output (I/O) tables for India included in the World Input–Output Database. Here is one specific example of how we use the India I/O tables to generate our employment creation estimates from clean energy investments. If a business invests $1,00,000 million equivalent on energy efficiency retrofits for an apartment building that it owns, we are able to measure, using the I/O tables, how much of the $1,00,000 the business will spend on paying wages and benefits to workers and on needed supplies (such as windows, insulation, and lumber), how much will be left over to keep as profits, and how many new workers will be hired by the window, insulation, and lumber companies as a result. We also examine this same set of questions for investment projects in renewable energy as well as spending on operations within the fossil-fuel energy sectors.

The specific renewable energy and energy efficiency sectors that we have modelled within India's I/O model are bioenergy, hydro, wind, solar and geothermal power among the renewable sectors; and building retrofits, industrial efficiency and electrical grid upgrades within energy efficiency. We then also report employment figures on coal and oil/gas production in India, using the same I/O model and estimating techniques. We show in the Appendix (posted on the EPW website along with this paper) the specific weighting of inputs through which we define each of these sectors within India's I/O model.

We report estimates of overall job creation generated by spending within the respective energy-producing sectors. This includes both direct and indirect employment. We present these overall job creation estimates within two scenarios. Under the first scenario, we assume domestic content is stable as renewable energy and energy efficiency investments expand significantly. Under the second, we assume that India will need to increase its proportion of imported inputs to meet the demands within the rapidly expanding renewable energy and energy efficiency sectors.

In Table 10, we first present our full set of results in terms of jobs created per $1 million spent. To facilitate comparisons on job creation levels across sectors, we then present summary figures in Table 11, focusing on weighted averages of the employment creation figures for renewables, energy efficiency and fossil fuels.

By assumption, we will focus primarily on the "Domestic Content Declines" figures presented in Table 10—that is to assume that, with all tradable activities linked to each of our renewable energy and energy efficiency sectors, India's import content rises by 20% relative to its current level. This is in response to the expansion of demand in that sector and our assumption, with this second set of calculations, that domestic resources will not be adequate for meeting the increased demand. This provides a more conservative assessment as to the capacity of India to expand clean energy activities on the basis of their current proportions of domestic resource use. It assumes, in other words, that India will need to increase its imports while advancing its clean energy investment scenario. India is a rapidly growing economy, and anticipates sustaining a strong growth trajectory over the coming 20 years. Still, building out clean energy sectors on a large scale will probably create significant strains on the country's resources of technological capacity and skilled labour.

We have used the following weighting scheme in aggregating the specific sectors within each energy-producing industry: With renewable energy, all sectors—bioenergy, hydro, wind, solar, and geothermal—are weighted equally. With energy efficiency, we have assigned a 50% weight to building retrofits, to reflect the centrality of this area of energy efficiency. We then weighted the other two energy efficiency sectors, industrial efficiency and electrical grid upgrades, at 25% each. With fossil fuels, we have weighted coal and oil/gas equally.[20]

Table 10: Employment Creation through Spending in Alternative Energy Sectors

Jobs per $1 million; figures are for 2009–10

	Domestic Content Stable			Domestic Content Declines		
	Direct Jobs	Indirect Jobs	Direct+ Indirect Jobs	Direct Jobs	Indirect Jobs	Direct+ Indirect Jobs
Renewables						
Bioenergy	562.6	61.2	623.8	562.6	60.7	623.3
Hydro	144.8	76.1	220.9	143.7	75.6	219.3
Wind	75.1	117.9	193.0	72.9	116.8	189.8
Solar	98.5	97.5	196.0	96.7	96.8	193.5
Geothermal	145.5	79.5	225.0	145.0	78.9	223.9
Weighted average for renewables	205.3	86.4	291.7	204.2	85.6	290.0
Energy efficiency						
Building retrofits	159.1	121.1	280.2	159.1	120.3	279.4
Industrial efficiency	105.5	88.1	193.6	103.0	87.4	190.4
Grid Upgrades	58.7	115.2	173.9	54.9	114.3	169.2
Weighted average for efficiency	120.6	111.4	232.0	119.0	110.6	230.0
Fossil fuels						
Coal	49.5	87.7	137.2	NA	NA	NA
Oil/natural gas	34.2	86.8	121.1	NA	NA	NA
Weighted average for fossil fuels	41.9	87.2	129.1	NA	NA	NA

Source: See Appendix (posted on the EPW website along with this paper).

Table 11: Summary Employment Figures

Direct + Indirect Employment with Domestic Content Decline

	Jobs per $ million USD
Renewable energy	290.0
Energy efficiency	230.0
Clean energy total (with renewable investments at 67% and efficiency at 33%)	270.9
Fossil fuels	129.1
Clean energy relative tofossil fuels (percentages)	+109.8%

Source: Table 10.

Overall Employment Creation

As we see in Tables 10 and 11, overall employment creation in India through spending in renewable energy and energy efficiency investments will be much higher than the current level of employment generation within the fossil fuel economy. This is true across all renewable energy and energy efficiency sectors. As we see in Table 10, this overall finding is not significantly affected by whether a decline in domestic content occurs when the level of clean energy investments expands. That is, following our assumption that domestic content in tradable sectors declines by 20% due to the expanded demand for clean-energy based inputs, the overall effect is to reduce direct and indirect employment by slightly less than two jobs per $1 million of spending in both renewable energy and energy efficiency—from 291.7 to 290.0 jobs per $1 million in renewables and 232 to 230 jobs in energy efficiency.

As we see in Table 10 with the "Domestic Content Declines" case, the bioenergy sector is by far the largest proportional source of job creation, with 623 jobs generated per $1 million in spending. These will be mostly jobs with low compensation and poor working conditions in agriculture. At the same time, significant new investments in bioenergy could provide the basis for raising productivity and working conditions in the sector.[21] In the other renewable energy areas—hydro, wind, solar and geothermal—total direct and indirect job creation ranges fairly narrowly, between 190 and 224 jobs per $1 million.

With our energy efficiency categories, building retrofits generates substantially more jobs per $1 million in spending, at 279 jobs under the "Domestic Content Declines" scenario. These are all jobs linked to the construction industry. With industrial efficiency and grid upgrades, the range is relatively narrow, between 169 and 190 jobs per $1 million.

These job figures are much larger than those for coal and oil/natural gas, which, respectively, are at 137 and 121 jobs per $1 million in spending. As such, India's fossil fuel sectors are significantly more capital intensive than even the relatively capital intensive clean energy sectors, such as wind and solar energy and grid upgrades.

The overall result in terms of job creation, as we see in Table 11, is that a combined renewable energy and energy efficiency investment agenda will create roughly twice the number of jobs in India than comparable levels of spending in the current fossil fuel industries.

Of course, it is critical to also consider the quality of these jobs being generated as well as the quantity. We have not, as yet, undertaken research on this issue for the Indian case. But in Pollin et al (2015) we have presented detailed analysis for the cases of Brazil, Germany, Indonesia, South Africa and South Korea, some of which could help shed light on comparable situations for India. These discussions include both quantitative and qualitative analyses around issues of gender, the proportions of formal and informal employment, and the educational attainment levels within the range of job categories associated with clean energy investments. Additionally, Baruah (2015) has written an important study focusing on opportunities for women in India's emerging renewable energy sector. She finds that "there is tremendous potential to create livelihoods for women" through new investments in renewable energy throughout India. However, she also emphasises that, at present, women's access to green technologies is limited by inadequate purchasing power and low social status. She concludes that women in India "can gain optimal traction from green initiatives only within the context of wider socially progressive pro-women policies" (p 73).[22]

Employment Creation through 1.5% of GDP Investment Programme

Table 12 presents our first set of figures through which we estimate the effects on overall annual employment levels through an Indian clean energy investment programme at the level of 1.5% of GDP.

Table 12: Employment Impact of Clean Energy Investment Programme Fossil Fuel Spending

Figures are jobs in Year 1 of 20-Year Programme

Assumptions of Programme:
- Total investment = 1.5% of GDP
  - o 67% clean renewables;
  - o 33% energy efficiency
- "Domestic Content Declines" scenario
- 70% of investment for capacity creation/production
- 30% for financing costs

Indian Labour Force in 2009–10 = ~ 470 million

	Clean Energy Programme	Fossil Fuel Spending	Net Employment Effects of Clean Energy Programme
Direct + Indirect Total Employment in Year 1	12.0 million	5.7 million	6.3 million
Direct + Indirect Employment as Share of Total Labour Force in Year 1	2.6%	1.2%	1.4%

Source: Generated from figures in Tables 10 and 11 and assumptions listed above.

Working within that framework, we have calculated the effects of the 1.5% of GDP investment programme, given a spending breakdown at two-thirds renewables and one-third energy efficiency. We also make two other assumptions. First, we continue to focus on the results from our "Domestic Content Declines" scenario. We then also assume that of the total amount of spending on the clean energy investment project, 30% is allocated to cover financing costs. This leaves 70% available for spending on creating capacity and producing, refining, transporting and marketing energy.

From these assumptions, we estimate that the total amount of direct plus indirect employment generated through the clean energy investment project at 1.5% of GDP would be about 12 million jobs. This is about 2.6% of the overall Indian labour force of 469 million people as of 2010.

To measure the net gains in employment, we need to also compare these figures with the job creation that would occur through maintaining spending in India's existing fossil fuel industry, as opposed to shifting funds into clean energy. We see in Table 12 that the same level of spending in India's coal, oil and natural gas sectors would create 5.7 million jobs. As such, the net gain in employment through shifting funds out of fossil fuels and into clean energy at the level of 1.5% of India's GDP would be 6.3 million jobs, or 1.3% of the country's 2010 workforce. The impact of the clean energy investment project would therefore be strongly positive in terms of employment, but its overall scope would be modest relative to the overall employment level in India.

In Table 13, we present our projections for employment creation in Year 20 of India's 20-year clean energy investment programme. These figures are based on two separate assumptions as to the average growth rate of labour productivity in India's clean energy sectors over this 20-year period—a 2.5% low-end average annual labour productivity growth rate assumption and a 5% high-end assumption.[23]

Table 13: Projected Employment Impacts of Clean Energy Investments after 20 Years under Alternative Labour Productivity Assumptions

Figures are jobs per year

Assumptions for 20-year employment projections
- Baseline year-one employment levels given in Table 8
- 20-year average annual GDP growth is 6.0%
- Average annual labour productivity growth ranges between 2.5% and 5.0 %
- Population figure is projected to 1.5 billion in 2035.
- Labour force/population ratio at end of 2035 equals 2009–10 ratio

Labour force at end of 2035 = ~588.0 million

	Scenario with 2.5% Average Annual Labour Productivity Growth	Scenario with 5% Average Annual Labour Productivity Growth	Midpoints between 2.5% and 5% Productivity Growth Scenarios
Direct + Indirect Total Employment	23.9 million	14.7 million	19.3 million
Year 20 Direct + Indirect Employment relative to Year 1 Employment	+99.2%	+22.9%	+60.8%
Direct + Indirect Employment as Share of Total Labour Force	4.1% (+1.5% relative to year 1)	2.5% (-0.1% relative to year 1)	3.3% (+0.7% relative to year 1)

Sources: Derived from Table 12 figures and assumptions listed above.

Working with these assumptions, as well as with the other assumptions on GDP growth, population and labour force participation listed on Table 13, we generate the following results:

(1) Assuming labour productivity increases at 2.5% per year, total employment creation through clean energy investments

will rise to about 23.9 million in Year 20. This is a nearly 100% increase relative to employment creation in Year 1. This strong gain in employment creation results through our assumption that GDP growth will average 6.0% per year over the 20-year clean energy investment cycle—a 3.5% faster rate than labour productivity in the clean energy sectors. GDP growth at 6.0% per year, in turn, means that clean energy investments will also be growing at 6.0% per year, to remain as a fixed 1.5% of GDP every year over the 20-year investment cycle.

(2) Under this 2.5% labour productivity growth assumption, employment creation through clean energy investments will rise to about 4.1% of India's Year 20 labour force relative to the 2.5% figure as of Year 1.

(3) Assuming average labour productivity in India's clean energy sectors increases at the higher-end rate of 5% over the 20-year investment cycle, employment creation will still be rising significantly, given that we assume GDP growth will average 6.0% per year. Year 20 employment creation through clean energy investments then reaches 14.7 million. This is still a nearly 23% increase over the Year 1 figure. Under this scenario, employment creation through clean energy investments reaches 2.5% of India's overall labour force in Year 20, basically the same labour force percentage that would occur in Year 1.

(4) In the last column of Table 13, we report midpoint employment creation figures, that are based on averaging Year 20 employment levels derived from both the 2.5% and 5.0% labour productivity growth assumptions. As we see, the midpoint figure is 19.3 million jobs, which is about 3.3% of India's Year 20 labour force.

Overall, as we see, employment creation through India's clean energy investment programme operating at 1.5% of GDP per year will expand significantly under a wide range of plausible assumptions as to the growth of labour productivity over the 20-year investment cycle. As such, we can conclude that the clean energy project for India, scaled at about 1.5% of GDP per year, will generate, first, huge reductions in CO_2 emissions while, concurrently, providing expanding employment opportunities throughout the country over the full 20-year investment cycle.

9 Conclusions

Controlling climate change will require that the entire global economy drastically reduce its reliance on oil, coal and natural gas. It is a widely held view—and perhaps a dominant perspective worldwide—that if consumption of fossil fuels does indeed need to be cut sharply, then it also follows that global economic growth will also have to decline significantly and employment opportunities will need to similarly contract.

However, the research we have presented here shows that, for the case of India, a healthy economic growth trajectory can rather become the basis for the most effective possible climate stabilisation strategy. Our study shows that, on the basis of conservative assumptions as to costs of expanding capacity in clean renewable energy and increasing energy efficiency, India can stabilise emissions per capita relative to 2012 levels and reduce emissions by 52% relative to the IEA's Current Policies (that is business-as-usual) framework for 2035. This would result through investing an additional 1.5% per year of GDP per year for 20 years in clean energy above the IEA's assumed investment level while India's economy grows at an annual rate of 6.0% per year over the 20-year investment cycle we have described.

We have also shown that this clean energy investment project can also advance human well-being in India because it would generate an increase of millions of jobs relative to maintaining India's existing fossil-fuel energy infrastructure. The basis for this result is straightforward. As we show, building a clean energy economy in India requires significantly more labour inputs per dollar (or rupee) of expenditure than maintaining India's existing fossil fuel infrastructure.

The economics Nobel Laureate Jan Tinbergen developed a well-known proposition that it is necessary to deploy separate policy tools to address distinct policy aims—that, in other words, trying to kill two birds with one stone is not likely to succeed. Yet despite Tinbergen, as we have shown, large-scale investments in clean renewables and energy efficiency are indeed capable of killing two birds with one stone. These investments can deliver dramatic reductions in CO_2 emissions in India over the course of roughly two decades while also generating about 6 million more jobs in the early phases of the investment cycle and probably in the range of 20 million more by Year 20. India could accomplish these emissions reduction and job creation goals while also eliminating entirely its reliance on nuclear energy. As such, the clean energy investment project that we have described for India is capable of making a major contribution towards the global imperative of climate stabilisation while concurrently advancing human welfare.

NOTES

1 Major "de-growth" proponents include Jackson (2009), Schor (2010) and Victor (2008). Their perspectives and others are presented in D'Alisa et al (2015). See a critique of this approach in Pollin (2015).

2 This is the trend growth forecast for 2012–40 in IEA (2014: 41).

3 The publication *Global Trends in Renewable Energy Investment 2014 (*Frankfurt School-UNEP Collaborating Centre and Bloomberg New Energy Finance) estimates total renewable investments as of 2012 were $7.5 billion. We assume that, of that total, approximately $3 billion was spent on clean renewables. The IEAs' *Energy Efficiency Market Report* 2013 estimated, as its most recent 2011 figure, that total energy efficiency investments in India were $9.5 billion (p 166; the *2014 Energy Efficiency Market Report* does not provide an updated overall investment figure). We therefore roughly estimate that current total clean energy investments in India are in the range of $13 trillion, which is 0.6% of 2012 GDP in USD.

4 See Chapter 1 of Pollin et al (2015) as well as Pollin et al (2014) for further discussions on this issue.

5 The 2010 GHG emissions data are the most recent figures presented in the World Development Indicators website: http://wdi.worldbank.org/table/3.9. For the most part, we utilise emissions figures from the IEA rather than the World Bank, because they provide more detail on the India case. But the World Bank figures are more detailed on all GHG emissions. The two data sources do differ modestly in reporting total global CO_2 emissions levels.

6 Details of these three IEA cases specifically for India are presented in IEA (2014a: 649). As we will make detailed references to the Current Policies case in particular later in this paper, it will be useful to provide the full set of features of this case. They include "Renewable Energy Certificate trade for all eligible grid-connected renewable-based electricity generation

technologies; National solar mission target of 20 GW of solar PV capacity by 2022; and increased use of supercritical coal technology," (p 649).

7 Figures for this paragraph are from US EIA (2013).

8 Thus, as we show in Pollin et al (2015), Table 2.1, CO_2 emissions are between 65 and 90 million tonnes per Q-BTU for biomass, biogenetic waste, biofuels, ethanol, biodiesel and liquids from biomass. By comparison, emissions are about 71 million tonnes for oil, 95 million tonnes for coal for residential and commercial use, and 53 for natural gas used as a fuel.

9 IRENA (2013) provides an excellent survey of the literature that specifically addresses these concerns.

10 The quotes in the text come from the news report by Rehman (2013). A follow up summary in the *Hindu Business Line*, 8/5/14, http://www.thehindubusinessline.com/economy/arunachalassam-row-over-subansiri-hydro-power/article6283440.ece. The full SANDRP report on the project is SANDRP (2013). Additional background and alternative perspectives on this question is provided in Das (2012), and Rajavanshi (2007).

11 US Bureau of Labor Statistics, "International Comparisons of Hourly Compensation Costs in Manufacturing, 2012," 8/9/13.

12 Chapter 4 of Pollin et al (2015) discusses the obstacles to expanding energy efficiency investments in depth.

13 Chapter 4 of Pollin et al (2015) provides a detailed literature survey on rebound effects.

14 Of course, balance-of-payments considerations will inevitably emerge here as well. Yet these are not likely to be a major problem. This is because, as mentioned above, any green growth programme for India will necessarily entail major reductions in fossil fuel consumption, and thereby, correspondingly, fossil fuel imports. Indeed, a successful green growth programme for India will relax the country's balance-of-payments constraint on growth that has emerged increasing due to rising fossil-fuel import dependency. Thus, between 1990 and 2014, India's fossil fuel imports have risen dramatically, from 1.8 to 5.5% of GDP. Further significant increases in this ratio are not sustainable.

15 India's per capita gross national income is much higher, at $5,000 in 2012, when measured in terms of purchasing power parity and international dollars (see World Development Indicators, http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD). It is not clear whether US current dollars or a PPP scale is most appropriate for measuring the costs of undertaking large-scale clean energy investments in India. For our purposes, we are, as above, choosing to, if anything, overstate these costs. With this aim in mind, it is therefore appropriate to work with the lower current US dollar scale in measuring India's GDP and related economic indicators.

16 Annual growth rate calculated from data based on World Development Indicators, World Bank.

17 The energy and emissions statistics are based on US EIA website.

18 *World Energy Outlook*, 2012, IEA.

19 This is approximately equal to the country's actual emissions levels per fossil fuel Q-BTU of consumption in 2010. In fact, if we allow that the relative proportion of coal supply falls while oil and natural gas rise, the average emissions level per Q-BTU would fall below 70 million tonnes.

20 In this paper, we have not constructed alternative weighting schemes to test for the robustness of our employment figures relative to the specifics of the assigned weights. However, in Pollin et al (2015) we did perform such robustness checks for the diverse cases of Brazil, Germany, Indonesia, South Africa and South Korea. We found that our employment estimates did not change to any significant degree through utilizing plausible alternative weighting schemes.

21 Pollin et al (2015) discusses this situation with respect to conditions in Brazil, Indonesia, South African and South Korea, with special reference to Brazil's currently functioning large-scale bioenergy sector. See, for further discussion on Brazil, the 2007 joint study sponsored by the OECD and the International Transit Forum (De Almeida, Fagundes and Bomtemto 2007).

22 Jain and Patwardhan (2013) also present useful perspectives on the qualitative aspects of employment generation through renewable energy investments in India.

23 The figures underlying our range of assumptions on labour productivity growth are presented in the Appendix.

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Appendix : Data Sources and Methodology for Estimates of Employment Creation through Clean Energy Investments in India

Data Sources

We obtain the 35-sector level Input–Output matrix for the year 2009–10 from the World Input–Output Database (http://www.wiod.org/new_site/home.htm). To obtain the employment figures, we also used the NSS Report No 537 (66/10/1) on Employment and Unemployment situation in India, 2009–10. It is the eight quinquennial survey on employment and unemployment conducted in the 66th round of NSS during July 2009–June 2010. The survey was spread over 7,402 villages and 5,252 urban blocks covering 1,00,957 households (59,129 in rural areas and 41,828 in urban areas) and enumerating 459784 persons (2,81,327 in rural areas and 1,78,457 in urban areas).

Methodology

The employment outcomes of investments in the renewable energy or energy efficiency sector are estimated using Input–Output (I–O) table of India.

The industrial categories in the I–O tables of India currently do not explicitly identify "Renewable Energy" or "Energy Efficiency." Nonetheless, the component activities of these sectors are captured within the explicitly defined industrial sectors that comprise the input–output model. For example, the electrical and optical components used for the manufacture of solar panels are categorised in the electrical and optical equipment industry. Therefore, if we can identify the various components and their weights that make up the Renewable Energy and Energy Efficiency (REEE) industry, we can study the impact of increased demand for REEE products and services. We construct the employment requirements table using India's input–output table and industry specific employment/output ratio. Multiplying the Leontief Inverse Coefficient Matrix by the industry-specific E/O ratios yields the employment requirements table, from which the number of jobs (both direct plus indirect) associated with a given amount of expenditure on the final demand for the products or services of a given industry or a set of industries. The weighing scheme used for estimations is presented in Table A1.

Estimating the Effects of Changing Domestic Content

We use data on imports and domestic production from the I–O tables of India in order to calculate the domestic content in each industry. For the constructed renewable energy sectors, as defined above, we then calculate weighted average domestic content figures for each energy sector.

The domestic content (DC_i) percentage of an industry *i* is calculated as:

DC_i=(Domestic Production$_i$)/(Domestic Production$_i$ + Imports$_i$)

The weighted domestic content for each energy sector is the sum of the domestic content of each component industrial sector multiplied by the weight of each industry as given in Table A. Therefore, the domestic content (DCc) of an energy sector, c, is estimated as:

$DC_c = \Sigma (DC_i * w_i)$ where w_i is the weight of industry *i* with category c.

Further details on our estimating methodology follow from the approach developed in Pollin et al (2015).

Table A1: Weighting Assumptions for Specifying Clean Energy Sectors within India's Input–Output Model

Category	I–O industry	Weights
Bioenergy	Agriculture, hunting, forestry and fishing	50%
	Coke, refined petroleum and nuclear fuel	12.5%
	Construction	25%
	Education	12.5%
Solar	Basic metals and fabricated metal	17.5%
	Electrical and optical equipment	35.0%
	Construction	30.0%
	Education	17.5%
Wind	Rubber and plastics	12.0%
	Basic metals and fabricated metal	12.0%
	Electrical and optical equipment	43.0%
	Construction	26.0%
	Education	7.0%
Geothermal	Mining and quarrying	15.0%
	Electrical and optical equipment	10.0%
	Construction	45.0%
	Education	30.0%
Hydro	Other non-metallic mineral products	18.2%
	Electrical and optical equipment	21.0%
	Construction	18.2%
	Education	42.9%
Weatherisation and Building Retrofits	Construction	100%
Industrial Energy Efficiency	Electrical and optical equipment	50.0%
	Construction	20.0%
	Education	30.0%
Grid Upgrades	Electrical and optical equipment	75.0%
	Construction	25.0%
Coal	Mining and quarrying	50.0%
	Manufacture of chemicals and chemical products	50.0%
Oil and Gas	Mining and quarrying	50.0%
	Coke, refined petroleum and nuclear fuel	50.0%
"Renewable Energy"	Bioenergy, hydro, wind, solar and geothermal	20% each
"Energy Efficiency"	Weatherization and building retrofits	50%
	Industrial energy efficiency	25%
	Grid upgrades	25%
"Fossil Fuels"	Coal, oil/gas	50% each

Source: Pollin et al (2014).