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AN EGALITARIAN GREEN GROWTH PROGRAM FOR INDIA

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Abstract: *In the spirit of Prof. Utsa Patnaik's 40 years of research work to date, this paper explores 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, within a framework of economic growth, to develop a unified program that can both increase well-being for workers, peasants and the poor through expanding employment opportunities while contributing significantly toward the global project of climate stabilization? Our findings show that advancing such a unified agenda is a realistic possibility within India. We assume that the Indian economy grows at an average annual rate of 6.0 percent over a 20-year period. 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 percent of GDP above its current trend rate. Working from this starting point, we find that India can 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.*

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.

Through her 40 years of research work to date, Utsa Patnaik has made seminal contributions that have substantially advanced understanding on this fundamental question. One of Patnaik's major research concerns has been on ways to overcome the obstacles that exist to providing both employment and food security to all people, regardless of what variant of capitalist, socialist, or mixed economies they happen to live under. Patnaik has emphasized repeatedly and forcefully in her research an obvious point that, nevertheless, still requires exactly such forceful repetition—that employment and food security are "the critical indicators of welfare" (2012, p. 12).

In much of her recent work, Patnaik has focused on how the global ascendency of neoliberal economic policies have led to a worsening of both employment and food security in most regions of the world. The main factors characterizing global neoliberalism are macroeconomic policies focused on maintaining low inflation rather than full employment; reducing the public sector, including public investments in agricultural development and other areas; eliminating or weakening pro-worker labor laws; eliminating barriers to international trade; and deregulating financial markets. Patnaik has shown how this neoliberal agenda has led to declining economic growth, a contraction in employment opportunities and worsening conditions for the rural poor. Indeed, Patnaik has explained in depth how, in the specific case of India, neoliberal policies for the agricultural sector have been the primary underlying factor leading to huge numbers of farmer suicides that have occurred since the mid-1990s.[1]

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 and other greenhouse gases 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 greenhouse gas emissions generated by human activity will need to fall, relative to current levels, by 40 percent as of 2030 and by 80 percent as of 2050 in order to control climate change. About 75 percent of all global greenhouse gas emissions are carbon dioxide (CO_2) emissions produced through burning fossil fuels—oil, coal, and natural gas—to produce energy. As such, any

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[1] Patnaik addresses the connection between the concurrent rise of neoliberalism and agrarian distress in India in, among other publications (2002) and (2007).See also Chandrasekhar (2012) for a more general analysis of the transition from state-directed development ("dirigisme") to neoliberalism in India.

program aimed at achieving the overall IPCC greenhouse emissions reduction targets is, necessarily, also a program 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, particularly 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 program that can both increase well-being for workers, peasants and the poor through expanding employment opportunities while contributing significantly toward the global project of controlling climate change?

If the answer to this question is "no," that then would leave us with two alternatives to consider. One is that India would need to face up to managing the painful tradeoffs between economic growth and climate stabilization. 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 greenhouse gas emissions.[2]

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 program which is capable of achieving both dramatic CO_2 emissions reductions and expanding employment opportunities throughout India. We can summarize the affirmative findings of our study 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 percent over this 20-year period.[3] 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 percent of GDP above its current trend rate, which was probably about 0.6 percent of GDP as of 2011- 2012.[4] That would bring total clean energy investments to about 2 percent of GDP in total. These clean renewable sources include solar, wind, geothermal,

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[2] 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).

[3] This is the trend growth forecast for 2012 – 2040 by in IEA 2014, p. 41.

[4] 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 percent of 2012 GDP in USD.

and small-scale hydro power, 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—i.e. residences, commercial buildings, transportation systems and industrial production. We deliberately work with relatively high-end estimates of the average costs of making these energy efficiency and clean renewable investments.

Why should investments in clean renewables increase by 1.5 percent 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 policymakers consistently propose clean energy/emissions reduction policy frameworks ranging between 1 – 2 percent of their country's GDP. Our approach for India therefore builds from such perspectives. That is, we are deliberately aiming to advance a framework whose scope is well within the range of what is broadly recognized as being realistic.[5]

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*.

The structure of this paper is as follows. In Section 2, we present perspectives on energy production and consumption as well as emissions levels for the world as a whole and India in particular. In Sections 3-5, we examine the prospects for non-renewable energy, clean renewable energy sources and energy efficiency investments respectively, for both India and the rest of the world. Section 6 briefly considers an industrial policy framework for advancing a clean energy investment project in India, including new financial allocation policies. The recently established New Development Bank could possibly serve as a major resource in this feature of the overall clean energy project.

In Section 7, we present a series of simple modeling exercises for considering how the Indian economy would operate under a 20-year clean energy investment project at an annual investment level that is 1.5 percent of GDP greater than the current trend investment level. Within the framework of our cost assumptions for both renewables and efficiency investments, we still demonstrate that India could achieve dramatic reductions in per capita CO_2 emissions while the economy still grows at an average rate of 6.0 percent per year.

[5] See Chaper 1 of Pollin et al. (2015) as well as Pollin et al. (2014) for further discussions on this issue.

In Section 8, we examine the effects on employment opportunities of this 20-year clean energy investment project for India. We find that, even after fully accounting for job losses resulting from the contraction of India's fossil fuel sectors, the net increase in employment demand from clean energy investments will be 6.3 million jobs. This is about 1.4 percent of India's labor force as of 2010. We also show that India's net increase in employment demand through clean energy investments will increase over the full 20 year investment cycle. This is because output will be growing more rapidly than average labor productivity in India's clean energy sectors.

This paper concludes with some brief observations reflecting on our major findings. That is, we show that it is realistic to anticipate that, within the 20-year time frame on which this study focuses, an egalitarian green growth program 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 45,000 million metric tons (mmt). In order to control climate change, the Intergovernmental Panel on Climate Change (IPCC) estimates that total emissions will need to fall by about 40 percent as of 2030, to 27,000 mmt, and by 80 percent by 2050, to about 9,000 mmt. Of the 45,000 mmt of total greenhouse gas (GHG) emissions, about 82 percent are generated by energy-based sources. This includes 33,615 mmt in carbon dioxide (CO_2) emissions from energy sources, equaling about 75 percent of total GHG emissions.[6]

We can obtain valuable perspective on the magnitude of the challenges ahead by considering the CO_2 emission 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 percent chance of meeting the goal of limiting the increase in average global temperature to 2^oC compared with pre-industrial levels," (IEA 2014a, p.

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[6] The 2010 GHG emissions data are the most recent figures presented in the *World Development Indicators* website: http://wdi.worldbank.org/table/3.9.

687). That is, the IEA believes that its 450/Low Carbon case provides a 50 percent chance for the world to control climate change.[7]

Under the IEA's 2035 Current Policies case, global emissions are at 43,400 mmt, which is more than twice as high as the IPCCs' 20,000 mmt 2030 target level. The situation is only modestly improved in the IEA's New Policies case, in which they project 2035 CO_2 emissions to total 37,163 mmt. Even under the 450/Low Carbon case, the IEA still projects global emissions to be 22,350 mmt. Of course, this is a dramatic improvement relative to the other two cases. But it is still 11 percent higher than the 20,000 mmt target for 2030. 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 stabilizing the climate. It cannot be a satisfactory situation when, even under the most aggressive policy framework for controlling climate change modeled by the IEA, we still face only a 50 percent chance of achieving success.

Total Energy Consumption and Carbon Emissions

To frame the analysis of this study, 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 consumption amounted to about 530 quadrillion BTUs (Q-BTUs) from all energy sources—including fossil fuels, all renewable sources and nuclear power. This is while total CO_2 emissions were at 31,615 mmt. On a per capita basis, global energy consumption averaged 85 million BTUs in 2012, and average per capita global emissions were at 4.5 metric tons.

TABLE 1 BELONGS HERE

The two leading countries in terms of both energy consumption and CO_2 emissions are China and the United States. But as important as the U.S. 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 therefore 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 program, given that the country presently accounts for 17.5 percent 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.

[7] Details of these three IEA cases specifically for India are presented in IEA (2014a), p. 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).

As of 2012, as we see in Table 1, India's total energy consumption was at 31.2 Q-BTUs, 5.9 percent of the global total, while its CO_2 emissions, at 1,953 mmt, was about 5.2 percent 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 25.4 M-BTUs in 2012. This is only 30 percent of the average level for both China and the overall global economy, and only 9 percent of the U.S. figure. That is, the average resident of the U.S. 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 mt, per capita emissions in India equaled only 36 percent of the global average and 10 percent of the U.S. figure.

Specifying the Climate Change Challenge

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 2030 emissions reduction target in terms of this per capita measure, within the framework of reducing the absolute level of carbon emissions by 40 percent, to around 20,000 mmt, within 20 years. With global population expected to rise to about 8.4 billion by 2030 and 8.7 billion in 2035, this means that carbon emissions will need fall from its current level of 4.5 mt to 2.3 mt 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. We can see this pattern clearly in Table 2, which divides all countries into five broad income categories, and shows the emissions per capita for each of the five income categories as of 2010. Starting with the upper panel of Table 2, we see that low income countries, averaging $592 in per capita GDP and with a total population of 846 million people, operate with emissions level of 0.3 mt per capita. Per capita emissions then rise to 1.6 mt for lower income countries, 3.4 for middle income countries, 5.4 for upper-middle income countries and 11.6 for high income countries. That is, on average, the 1.3 billion residents of high-income countries generate 7.2 times more emissions than the 2.5 billion people living in lower-middle income countries, and 38 times more emissions than the 846 million people living in low-income countries.

TABLE 2 BELONGS HERE

The lower panel of Table 2 gives further perspective on this relationship. Of the total of 60 countries in which emissions per capita are currently at or below 2.3 mt—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 mt, average GDP per capita was $3,058. By contrast, of the 13 countries in which per capita emissions were above 10 mt, average GDP per capita was $33,700.

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 mt within 20 years must start with the 13 countries whose emissions levels are over 10.0 mt, and especially the United States, 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 stabilize 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 commercialization 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 mmt per Q-BTU, are, respectively, about 50 percent higher than those for oil and 80 percent higher than with natural gas. Oil emissions are therefore also about 20 percent 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 percent of global coal usage.

There are still two alternative possibilities to reduce emissions levels while continuing to utilize 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 commercialized.

With India specifically, as of 2012, 75 percent of its energy supply was provided by non-renewables, of which only 1 percent 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 percent 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.[8]

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 percent 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 favorable. 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 OECD, which ranged at about 7 – 12 cents per kilowatt hour.[9]

With respect to India specifically, recent assessments are consistently quite favorable 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, p. 19).

The increasing technological potential for renewable energy in India was also strongly supported in an important 2013 paper by Prof. S.P. Sukhatme, "Can India's Future Needs of Electricity be Met by Renewable Energy Source? A Revised Assessment." The "revised assessment" to which Prof. Sukhatme is referring is that,

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[8] Figures for this paragraph are from U.S. EIA (2013).
[9] As we discuss in detail in Pollin et al. (2015), if we assume that through either a carbon tax or cap that a global carbon price is set at $75 per ton—which is the pricing framework underlying the modeling on this issue from the U.S. EIA—and we also assume a simple cost-plus mark-up pricing framework, then the impact on fossil fuel prices would be 250 percent for coal, 64 percent for natural gas, and 21 percent for oil.

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 certainly 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.[10] This issue is particularly significant in the case of India, in which solid biomass and waste account for fully 23 percent 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 raised about a rapid expansion of bioenergy production is that it will raise food prices. This would have adverse effects especially on low-income people in developing countries, for whom food purchases typically constitute between 50 - 70 percent of their total consumption basket. Of course, the production of many forms of bioenergy requires agricultural products as basic inputs. Large increases in the production of bioenergy will therefore increase overall agricultural production and shift resources, at least to some extent, towards meeting demand from the non-food bioenergy market rather than expanding food supply (Sexton et al., 2008). Patnaik herself has raised this concern forcefully, observing that:

> The new element is that with increasing uncertainty faced by advanced industrial nations over their control of global energy resources, there is a reversion to the land to provide energy just as was the case during the first industrialization: corn in the North and sugarcane in Brazil is being diverted on a large scale for producing ethanol. This has serious implications for food security in the South. (2012, p. 20).

This is clearly a major concern with respect to bioenergy. However, over the past decade, the dominant factor explaining global increases in food prices—including especially during the huge global food price bubble from 2004 to 2008—has been the rise in speculative activity on the commodities futures markets, not the expanded demand for agricultural output generated by bioenergy production (see Gilbert, 2010; Ghosh, Heintz and Pollin 2012; and Pradhananga 2014).

It is also the case that the development of a clean bioenergy sector could potentially contribute toward both reducing the threat of climate change and addressing concerns over food security. This is true first because droughts, floods, and extreme

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

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 minimized 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.[11]

We confront similarly challenging issues with respect to the development of hydro power, 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 dam 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' organization Krishak Mukti Sangram Samiti." The South Asia Network on Dams, Rivers and People (SANDRP) has characterized this dam project as "another chapter of environmental subversion in Northeast India."[12]

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 utilize 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 summarized by Kosnik (2010), "Such small generation facilities have very few of the negative riverine impacts to which larger, more conventional hydropower plants have been prone to," (2010, p. 5512). A recent World Bank assessment of renewable energy potential in India concludes that small-scale hydro is a "very attractive" but still "largely untapped" resource for India, especially in Himachal Pradesh, Jammu and Kashmir, and Uttarakhand, which, according to this study,

[11] IRENA (2014) provides an excellent survey of the literature that specifically addresses these concerns. Citing work from the Food and Agriculture Organization (FAO), this survey reports, among its findings, that an abundance of land area exists to maintain food security on a global scale while still supporting a major expansion of bioenergy production. However, the study does recognize that most of the land that could be newly cultivated for energy crops are concentrated in Africa and Latin America. It is possible that India would need to rely, to some extent, on imported raw materials to build a significant bioenergy sector while still maintaining their priority of establishing and sustaining food security for its population. However, any such increase in import requirements would not affect the economy's overall balance of payments to the extent that energy crop imports would be substituting for the country's current high level of oil and natural gas imports.

[12] 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).

"have 65 percent of India's small hydropower resource and among the lowest generation costs," (Sargsyan et al. 2010, p. 18).

Despite the much more favorable environmental framework in which small-scale hydro projects operate, 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," (2014, p. 78). Yet, Baker does not dismiss the potential opportunities for small-scale hydro in India outright. 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, p. 84). It is notable that these recommendations are closely aligned with those discussed above by Patnaik for achieving food security throughout rural India.

Cost Estimates for Clean Renewables in India

IRENA has produced estimates of the total levelized costs of electricity generation specifically for the case of India. We show these figures in Table 3, along with comparable figures for the United States. As we see in Table 3, other than with solar energy, the average levelized costs for India are lower than those for the U.S. These average costs are about 11 percent lower for large-scale hydro (we do not have figures for small-scale hydro in the U.S.); 20 percent lower for onshore wind; and 60 percent lower for bioenergy. In addition, as discussed before, the levelized 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 BELONGS HERE

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 U.S. case. That is, working from data developed by the U.S. 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 - 2035, the capital expenditures required to expand renewable capacity in the U.S. 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 U.S. 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 percent lower than in the U.S. case, i.e. at about $200 per Q-BTU. We base this assumption on the fact that average labor costs in India are dramatically lower than those in the U.S. For example, the U.S. Labor Department has most recently reported that average hourly compensation in Indian manufacturing is about 4 percent of the U.S. figure—i.e. $1.46 per hour in India versus $35.67 in the U.S.[13] Comparative labor costs in Indian versus U.S. agriculture, to supply the raw materials for bioenergy, are almost certainly within the same range as those for manufacturing. This relative unit labor cost differential is likely the primary factor explaining the fact that total levelized electricity costs from bioenergy in India are, on average, 60 percent lower than those in the U.S.

It is also probable that non-labor costs will be higher in India's clean energy sectors. Nevertheless, these cost differentials for all other productive inputs in clean energy—i.e. materials, transportation, energy, and management—are not likely to be more than 50 percent higher than those in the U.S. If we assume that those other inputs are within the range of 50 percent above those in the U.S., 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 emphasize 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 raising energy efficiency levels in all four major areas of energy usage—i.e. 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:

[13] U.S. Bureau of Labor Statistics, "International Comparisons of Hourly Compensation Costs in Manufacturing, 2012," 8/9/13.

> 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, p. 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 characterizes 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 percent of current total energy consumption levels.[14]

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 longstanding question with efficiency investments is, given that they will produce significant energy savings, then why haven't 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

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[14] Another recent detailed discussion on the costs and potential savings available to India through energy efficiency investments is International Energy Agency (2013b), Chapter 12. This discussion summaries its perspective on India as follows: "Significant progress has been made in creating a sustainable policy and regulatory framework in India since the enactment of the Energy Conservation Act of 2001….Given India's significant projected energy demand growth, there is enormous potential for expansion in the energy efficiency market," (IEA 2013, p.162).

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.[15]

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

TABLE 4 BELONGS HERE

It is not surprising that average costs to raise energy efficiency standards would be significantly higher in industrialized economies. This is because a high proportion of overall energy efficiency investments are labor costs, especially projects to retrofit buildings and industrial equipment. However, these wide differences in cost estimates are not simply resulting from variations in labor and other input costs by regions and levels of development. As noted above, the World Bank estimate of $1.9 billion per Q-BTU includes both industrialized and developing countries, while the McKinsey $11 billion per Q-BTU estimate—nearly 6 times greater than the World Bank figure—is primarily coming from developing country projects.

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 at least 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, i.e. the average figure estimated in the McKinsey study, which is, again, nearly 6 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

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

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 byproduct 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.[16] 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, in any case, 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.

7. 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, well 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 utilizing 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 program 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

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

prospects of its clean energy investments? To maintain a flexible approach on this question, we develop in the next section of the study two sets of employment creation estimates based on two scenarios. In the first scenario, domestic content remains stable in the relevant sectors as clean energy investments expand, while in the second scenario, we assume domestic content declines by 20 percent in the relevant sectors.[17]

Of course, 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. Some of the broad issues that India will need to consider in implementing clean energy industrial policies have been well summarized in Mazzucato's important recent study, *The Entrepreneurial State* (2014). Indeed, in developing the main general concepts of her study—i.e. the concepts of "the entrepreneurial state" and "innovation-led growth,"—Mazzucato concentrates in detail on how such concepts can be advanced most effectively in promoting the "green industrial revolution." She documents both successes and failures with green industrial policies—in which she observes successes to date having mainly occurred in Western Europe and China, while, in her view, the US and UK have been less successful. The primary distinction between more or less successful experiences has been the willingness of governments to commit major resources over the long-term, as opposed to the more sporadic levels of commitments coming from the US and UK.

In all cases, 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 in several recent studies. One recent study by Spratt, Griffith-Jones and Ocampo (2013), *Mobilizing Investment for Inclusive Green Growth in Low-Income Countries*, examines 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. Two of the major findings of this study are as follows:

1. The importance of looking at "how best to structure investment vehicles that combine the detailed local knowledge required to overcome information

[17] 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 program for India will necessarily entail major reductions in fossil fuel consumption, and thereby, correspondingly, fossil fuel imports. Indeed, a successful green growth program 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 percent of GDP. Further significant increases in this ratio are not sustainable

asymmetries, with the scale required to minimize transaction costs and achieve diversification benefits;" and

2. The need to reduce the expectations of high returns on these investments from institutional investors. The authors 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. Unless investors can be persuaded to adopt more reasonable expectations, alternative sources of finance may been needed if the goal of generating inclusive green growth in low-income countries is to be achieved," (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 (2014) emphasizes in his recent assessment, 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, p. 12). Chandrasekhar himself expresses strong concerns that the NDB may not meet higher standards as a development bank than the Bretton Woods institutions. To a significant degree, this is because, as he argues, the NDB "may not be too different from and completely independent of the World Bank and the IMF," (2014, p. 12). 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.

8. 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 U.S. dollars).[18] Overall energy consumption was 31.2 Q-BTUs and overall CO_2 emissions from energy sources were 1,953 mmt. On a per capita basis, India's overall energy consumption was 25.0 million

[18] 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 U.S. 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 U.S. dollar scale in measuring India's GDP and related economic indicators.

BTUs, which is about one-third the global average of 75.7 million BTUs. Emissions per capita were 1.6 mt, which is, again roughly one-third of the 4.5 mt global average. It is also about 40 percent below the targeted per capita global average emissions of 2.3 mt needed for achieving the 20-year global CO_2 emissions reduction target.

TABLE 5 BELONGS HERE

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 USD GDP, was 139 percent 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 program.

From 1990 – 2012, the Indian economy grew at a rapid average annual rate of 6.4 percent. Over a more recent and narrow time frame, i.e. between 2003 – 12, India's annual GDP growth was significantly higher still, averaging 8.0 percent.[19] This sustained strong growth performance also generated rapid increases in energy consumption throughout the country. Thus, India's total energy consumption between 1990 – 2012 grew from 12.6 to 31.2 Q-BTUs. This amounts to a 4.4 percent average annual growth rate, meaning that the growth in India's overall energy consumption over this time period was well below its 6.4 percent GDP growth rate. It is therefore not surprising that the country's provisioning of energy services is still seriously underdeveloped.[20] As of 2011, 24.7 percent 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.[21] 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 percent, much less the 8.0 percent rate attained between 2003-12 or even something still faster, while also maintaining its existing energy infrastructure

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[19] Annual growth rate calculated from data based on *World Development Indicators*, World Bank.
[20] The energy and emission statistics are based on US EIA website.
[21] *World Energy Outlook*, 2012, IEA.

more or less intact, the result will be to generate a major increase in the country's CO_2 emissions.[22] In Table 6, we can see what the impact would be of a 6.0 percent average annual growth rate under what IEA has developed as its 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 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 percent increase relative to the actual 2012 level.

TABLE 6 BELONGS HERE

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 percent between 2012 and 2035 under the Current Policies scenario, while oil, the second largest energy source, remains nearly constant , between 22.5 percent 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—i.e. primarily biomass such as wood, which falls from 24.6 to 13.4 percent of India's total energy supply. That 11 percentage point loss of high-emissions renewables is replaced by the projected percentage increase in coal, along with increases in natural gas (+ 2.8 percentage point), nuclear (+1.5 percentage points) and clean renewables (+0.8 percentage 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 percent, from 1,953 mmt in 2012 to 4,666 mmt 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 mt between 2012 and 2035, a rough doubling of per capita emissions. This 3.1 mt figure for 2035 would be 35 percent above the overall global target of 2.3 mt 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

[22] As one example of a still faster GDP growth projection, the Transport Research Wing of the Ministry of Road, Transport and Highways submitted a 2012 report to the Indian Planning Commission based on a range of 8.0 – 9.5 percent average annual GDP growth forecasts over 2009 – 2030. See: http://planningcommission.nic.in/sectors/NTDPC/Working%20Group%20Reports/Roads/Report%20of%20Working%20Group%20on%20Roads_Submitted%20to%20the%20Govt%20on%20July%204th,%202012.pdf; Table 2.2, p. 15.

worldwide emissions reduction project along the lines specified by the IPCC if India's per capita emissions were to increase by 80 percent within 20 years.

The situation does of course improve under the IEA's Low Carbon/450 case. scenario. We noted the main features of the Low Carbon/450 case above. In this scenario, overall emissions in 2035, at 2,942 mmt, are 37 percent lower than in the Current Policies case. Most of the improvement here is the result of substantially reducing reliance on coal, from 48 to 29 percent of India's total energy supply. A combination of all other energy sources are then assumed to substitute for this reduced consumption of coal. The largest percentage increases in the Low Carbon/450 case are with nuclear power and clean renewables. Nuclear power consumption rises from 2.5 to 7.1 percent, and clean renewables increases from 2.5 to 9.0 percent. Within clean renewables, the biggest area for expansion is projected to be large-scale hydro, which itself rises from 1.3 to 3.6 percent.

As a result of these changes in India's overall fuel mix under the IEA's 2035 Low Carbon/450 scenario is that per capita emissions rises moderately to 2.0 mt in 2035 relative to the actual 2012 figure of 1.6 mt. For India to moderately increase its per capita emissions under this Low Carbon/450 scenario would represent a substantial accomplishment within an economy in which, according to the IEA's assumptions, GDP growth would still be averaging 6.0 percent a year through 2035. But there are still two major problems with even this favorable projection. The first is that the emissions reductions relative to the Current Policies scenario are driven primarily by expansions in both nuclear and large-scale hydro capacity. As we have discussed above, both of these scenarios will create major environmental or public safety problems of their own. The second is that, even if India did follow this path to emissions reductions, it would still mean forgoing the opportunity to advance a far more effective program of large-scale investments in energy efficiency and clean renewables, including small-scale hydro.

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—i.e. investments in clean renewable energy and energy efficiency—at a rate of 1.5 percent of GDP annually over a full 20-year period. For the purposes of our discussion, we assume that this 1.5 percent of GDP is allocated with 1 percent of GDP funding the expansion of clean renewable production while 0.5 percent of GDP is channeled into energy efficiency investments.

TABLE 7 BELONGS HERE

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 percent. This is the IEA's average annual growth projection over 2012 – 2040 for India. This GDP growth rate is, of course, well below both India's actual growth trajectory from 2003 – 2012 of 8.0 percent as well as the projections ranging between 8.0 – 9.5 percent used in at least some modeling exercises by India's Planning Board.[23]

As Table 7 shows, with a 6.0 percent 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 percent of $4 trillion per year for renewables, which is $40 billion, and 0.5 percent 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 for clean renewable capacity expansion and efficiency savings, we then generate estimates for how much new clean renewable capacity would be built or energy savings achieved within our additional set of assumptions—i.e. India averages 6.0 percent GDP growth over the full 20-year investment cycle; 1 percent of annual GDP is invested in clean renewable capacity; and 0.5 percent of annual GDP goes towards 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.

TABLE 8 BELONGS HERE

[23] See, again, the reference to the 2012 study for the Indian Planning Commission cited in footnote #24 above.

We then show the net effects of these investment projects in row 4 of Table 8. That is: 1) through investing 1 percent 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 percent 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 3-year delay before actual investment spending begins.

TABLE 9 BELONGS HERE

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 percent 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 safely 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 program. This is a reduction of 32.9 Q-BTUs, or 51 percent, 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 mmt per Q-BTU.[24] Under this assumption, India's overall emissions fall from the IEA's Current Policy scenario of 4,666 to 2,219 mmt, again, a 52 percent decline. Emissions per capita at the end of the 20-year investment cycle are then 1.5 mt. This 52 percent decline in India's per capita emissions would result within our clean energy investment

[24] 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 mmt.

program while the economy was growing at a 6.0 percent average annual rate and population would have increased from 1.2 to 1.5 billion. It also assumes that no new clean energy investments take place in the first three years of the 20-year investment cycle.

Finally, we note that our 2035 emissions per capita figure of 1.5 mt at the end of the 20-year investment cycle is 25 percent lower than even the figure that the IEA projects for 2035 under its 450/Low Carbon scenario. Moreover, with our investment project, we have achieved this dramatic reduction in emissions while also 1) eliminating nuclear energy altogether; and 2) without building any new large-scale hydro energy projects. Our approach, rather, depends first, on major gains in energy efficiency—specifically, bringing down India's overall energy consumption by 2035 to 36.8 Q-BTUs, which is 26 percent lower than the 50 Q-BTU total consumption figure under the IEA's 450/Low Carbon scenario. We then expand clean renewables to 5.1 Q-BTUs, or 14 percent of total energy supply as of 2035.

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, i.e. 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. The specific renewable energy and energy efficiency sectors that we have modeled within India's national input-output 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 input-output model and estimating techniques. We show in the Appendix the specific weighting of inputs through which we define each of these sectors within India's national input-output 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. Our basic calculation 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 percent 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.

In Table 10, we first present our full set of results in terms of jobs created per $1 million USD 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 under the stable domestic content assumption.

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 percent 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 percent each. With fossil fuels, we have weighted coal and oil/gas equally.[25]

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. The results are not significantly affected by a decline in domestic content as investment in clean energy expands. That is, following our assumption that domestic content in tradable sectors declines by 20 percent due to the expanded demand for clean-energy based inputs, the overall effect is to reduce direct and indirect employment by slightly less than 2 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.

TABLE 10 and 11 BELONGS HERE

Focusing for the moment on the case of stable domestic content in Table 10, we see that the bioenergy sector is by far the largest proportional source of job creation, with 624 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.[26] In the other renewable energy areas—hydro, wind,

[25] 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.

[26] 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,

solar and geothermal—total direct and indirect job creation ranges fairly narrowly, between 193 – 225 jobs per $1 million.

With our energy efficiency categories, building retrofits generates substantially more jobs per $1 million in spending, at 280.2 jobs. These are all jobs linked to the construction industry. With industrial efficiency and grid upgrades, the range is relatively narrow, between 174 - 194 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 emphasizes 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).[27]

Employment Creation through 1.5% of GDP Investment Program

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 program at the level of 1.5 percent of GDP.

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for further discussion on Brazil, the 2007 joint study sponsored by the OECD and the International Transit Forum (De Almeida, Fagundes and Bomtemto 2007).

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

TABLE 12 BELONGS HERE

Working within that framework, we have calculated the effects of the 1.5 percent of GDP investment program, given a spending breakdown at two-thirds renewables and one-third energy efficiency. We also make two other assumptions. First, we now use the results from our "Domestic Content Declines" scenario. 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 labor.

We then also assume that of the total amount of spending on the clean energy investment project, 30 percent is allocated to cover financing costs. This leaves 70 percent 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 percent of GDP would be about 12 million jobs. This is about 2.6 percent of the overall Indian labor 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 percent of India's GDP would be 6.3 million jobs, or 1.3 percent 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 program. These figures are based on two separate assumptions as to the average growth rate of labor productivity in India's clean energy sectors over this 20-year period—a 2.5 percent low-end average annual labor productivity growth rate assumption and a 5 percent high-end assumption.[28]

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[28] The figures underlying our range of assumptions on labor productivity growth are presented in the Appendix.

TABLE 13 BELONGS HERE

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

1. Assuming labor productivity increases at 2.5 percent per year, total employment creation through clean energy investments will rise to about 23.9 million in Year 20. This is a nearly 100 percent 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 percent per year over the 20-year clean energy investment cycle—a 3.5 percent faster rate than labor productivity in the clean energy sectors. GDP growth at 6.0 percent per year in turn means that clean energy investments will also be growing at 6.0 percent per year, to remain as a fixed 1.5 percent of GDP every year over the 20-year investment cycle.

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

3. Assuming average labor productivity in India's clean energy sectors increases at the higher-end rate of 5 percent over the 20-year investment cycle, employment creation will still be rising significantly, given that we assume GDP growth will average 6.0 percent per year. Year 20 employment creation through clean energy investments then reaches 14.7 million. This is still a nearly 23 percent increase over the Year 1 figure. Under this scenario, employment creation through clean energy investments reaches 2.5 percent of India's overall labor force in Year 20, basically the same labor 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 percent and 5.0 percent labor productivity growth assumptions. As we see, the midpoint figure is 19.3 million jobs, which is about 3.3 percent of India's Year 20 labor force.

Overall, as we see, employment creation through India's clean energy investment program operating at 1.5 percent of GDP per year will expand significantly under a wide range of plausible assumptions as to the growth of labor productivity over the 20-year investment cycle. As such, we can conclude that the clean energy project for India, scaled at about 1.5 percent 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. CONCLUSION

We began this paper by emphasizing the simple but fundamental observation by Utsa Patnaik that employment and food security are the "critical indicators" of human welfare. We then brought into consideration an equally important issue, i.e. ecological sustainability, and, specifically, the imperative of stabilizing the global climate. We then introduced a third major issue. This is the unavoidable fact that to stabilize the climate will require the entire global economy to drastically reduce its reliance on oil, coal and natural gas as the primary sources of energy.

It is widely argued that advancing human well-being is in conflict with the goal of climate stabilization. This would be because, under most circumstances, raising living standards entails, among other things, a favorable rate of economic growth. Further, maintaining a healthy economic growth trajectory, in most situations to date, generates comparable growth rates in energy consumption. This is the logic behind assuming that climate stabilization will require significant reductions in economic growth.

However, the project we have described here for India shows that a healthy economic growth trajectory can rather become the basis for the most effective possible climate stabilization 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 stabilize emissions per capita relative to 2012 levels and reduce emissions by 52 percent relative to the IEA's business-as-usual framework for 2035 through investing 1.5 percent per year of GDP per year for 20 years in clean energy. This is while India's economy would still grow at an average annual rate of 6.0 percent over the 20-year investment cycle we are proposing.

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 labor inputs per dollar (or rupee) of expenditure than maintaining India's existing fossil fuel infrastructure. We established this result entirely through calculations based on the data within the input-output tables for the Indian economy. This result is therefore fully independent of whether or not clean energy investments are also capable of reducing CO_2 emissions.

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. Nevertheless, despite Tinbergen, as we have seen, 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. As such, the clean energy investment project that we have described here for India is capable of making a major contribution toward the global imperative of climate stabilization while concurrently advancing human welfare in one of the most critical ways identified by Utsa Patnaik—that is, by generating an increase in employment opportunities throughout the country.

Appendix
Methodology and Data Source for Aggregate Employment Estimates

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 categorized 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 A2.1.

TABLE A.1 BELONGS HERE

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 to June, 2010. The survey was spread over 7402 villages and 5252 urban blocks covering 100957 households (59129 in rural areas and 41828 in urban areas) and enumerating 459784 persons (281327 in rural areas and 178457 in urban areas).

Estimating and Changing Domestic Content of Clean Energy Investments

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:
$DC_i = (\text{Domestic Production}_i) / (\text{Domestic Production}_i + \text{Imports}_i)$

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 A2.1. Therefore, the domestic content (DC_c) 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.

Projected Estimates of GDP and Labor Productivity Growth Rates

The estimated projections of the annual growth rates of GDP and labor productivity are based on the OECD Economic Outlook (2012), Volume 1. According to this study, India's potential growth rate of real GDP is almost 6.5 percent *per annum* over the period of 2018-2030. So, in this study, since our 17-year investment period coincides with it, we have projected real GDP of India to grow at an annual rate of 6.5 percent. The OECD (2012) study also projects labor productivity to grow at an annual rate ranging from 5.3 percent over the period 2012 -2017 to 4.6 percent over the period 2018-30. We believe that this projected potential growth rate of labor productivity is on the higher side. Therefore, we have provided three types of projected employment figures based on three different scenarios of growth rates of labor productivity in India: high (5 percent), low (2.5 percent) and a midpoint between these two (3.75 percent).

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

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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 *(Millions of metric tons)*	Per capita CO_2 Emissions *(Metric tons)*
World	529.8	74.0	31,615	4.5
China	115.3	85.4	8,229	6.0
United States	84.7	269.8	5,043	16.1
India	31.2	25.0	1,953	1.6

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

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

A) Per capita income, population and emissions

Income Categories	Average GDP per Capita ***(2005 PPP U.S. Dollars)***	Total Population	Average Emissions per Capita ***(Metric tons)***
Low	$592	846 million	0.3 mt
Lower Middle	$1,920	2.5 billion	1.6 mt
Upper Middle	$7,340	2.4 billion	5.4 mt
High	$37,720	1.3 billion	11.6 mt

B) Countries with low, medium, and high per capita emissions

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

Source: World Bank (2014), "World Development Indicators," Tables 1.1, 3.8, 3.9, and authors' calculations of underlying metadata

Table 3.
Estimated Levelized Costs of Electricity (LCOE) in India and the U.S.
Figures are USD cents per kilowatt hour (kWh)

	India *Estimates for 2011; in 2011 USD*		United States *Reference case for 2017in current USD*	
	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 (2012)

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, p. 29)	455 projects in 11 industrial and developing countries	$76 per ton of oil equivalent (TOE)	$1.9 billion per Q-BTU ***(conversion: 1 Q-BTU = ~ 25,200 TOE***
McKinsey and Co. (2010, p. 27)	Africa, India, Middle East, South East Asia, Eastern Europe, China	----	$11 billion per Q-BTU
United States National Academy of Sciences (2010; as summarized in Pollin et al. 2014)	United States	----	~ $29 billion per Q-BTU for buildings, industry

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 *Million metric tons*	1,953 mmt	31,615 mmt
Per Capita Energy Consumption *Million BTUs/person*	25.0 million BTUs	75.7 million BTUs
Per Capita CO_2 Emissions *Metric tons of CO_2 emissions/person*	1.6 mt	4.5 mt
Emissions Intensity Ratio *CO_2 emissions/Q-BTUs*	62.6	60.0
Energy Intensity Ratio *Q-BTUs/$1 trillion USD GDP*	17.0	7.1

Source: IEA (2014).

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

(1)	(2) 2012 Actual	(3) 2035 IEA Current Policy Scenario	(4) 2035 Low Carbon/450 Case
Total Energy Consumption (in Q-BTUs)	31.2	67.7	50.0
Energy Mix:			
■ **Coal**	44.9%	47.7%	28.7%
■ **Oil**	22.5%	25.4%	21.9%
■ **Natural Gas**	6.2%	9.0%	13.3%
■ **Nuclear**	1.1%	2.5%	7.1%
■ **High-Emissions Renewables**	24.6%	13.4%	20.1%
■ **Clean Renewables**	1.7%	2.5%	9.0%
o **Hydro**	1.4%	1.3%	3.6%
o **All others**	0.4%	1.0%	5.4%
Total CO_2 Emissions (million mt)	1,953	4,666	2,942
Emissions Intensity Ratio *Emissions per Q-BTU (mmt/Q-BTU)*	62.3	68.9	58.8
CO_2 Emissions per capita (mt)	1.6 (*population = 1.2 billion)*	3.1 (*population = 1.5 billion)*	2.0 (*population = 1.5 billion)*

Sources: IEA (2014).
Notes: A)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. Note that the figures from the IEA differ significantly from the other main data sources, the U.S. 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 percent below the IEA figure. We rely here on the IEA figures because they provide fuller energy consumption projections for India through 2040.
B) We have derived the emissions figures for the Low Carbon/450 case by assuming an average emissions level of 70 mmt per Q-BTU for fossil fuels and high-emissions bioenergy. The figure reported by the IEA itself (p. 661) is significantly lower, at 2,152 mmt. But under this scenario, India is consuming 42 Q-BTUs of either fossil fuel or high-emissions bioenergy; this would then imply that average emissions per Q-BTU of either fossil fuel or high-emissions bioenergy would be 55 mmt. This is an implausibly low figure, and is, in any case not supported by any research results.

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.

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 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 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.

Table 9.
Impact of Clean Energy Investment Program 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	4,666 mmt	2,219 mmt *(Based on 70 mmt average emissions per Q-BTU for fossil fuels)*
Total CO_2 Emissions per capita (*with population = 1.5 billion)*	3.1 mt	1.5 mt

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

TABLE 10.
Employment Creation through Spending in Alternative Energy Sectors

Jobs per $1 million USD; figures are for 2009-2010

	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.

Table 11.
Summary Employment Figures

Direct + Indirect Employment with Stable Domestic Content

	Jobs per $ million USD
Renewable Energy	291.7
Energy Efficiency	232.0
Clean Energy Total ***(with renewable investments at 67% and efficiency at 33%)***	271.9
Fossil Fuels	129.1
Clean Energy relative to Fossil Fuels ***percentages***	+110.6%

Source: Generated from Table 10. Underlying calculations from Appendix.

Table 12.
Employment Impact of Clean Energy Investment Program vs. Fossil Fuel Spending

Figures are jobs in Year 1 of 20-Year Program

Assumptions of Program:

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

Indian Labor Force in 2009-10 = ~ 470 million

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

Source: Generated from figures in Tables 10 and 11. See Appendix for details.

Table 13.
Projected Employment Impacts of Clean Energy Investments after 20 Years under Alternative Labor 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 labor productivity growth ranges between 2.5 - 5.0 %
- Population figure is projected to 1.5 billion in 2035.
- Labor force/population ratio at end of 2035 equals 2009-10 ratio

Labor force at end of 2035 = ~588.0 million

	Scenario with 2.5% average annual labor productivity growth	Scenario with 5% average annual labor 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 Labor 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: Generated from figures in Tables 10 and11. See Appendix for details.

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%
Weatherization 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. (2014a)