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THINK PIECE

Global Green Growth for Human Development

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ABSTRACT

The world is not on track to achieve climate stabilization: a global mean temperature between 1.5^{0}C to 2^{0}C above pre-industrial levels no later than 2100—the goal of the Paris Agreement. The paper illustrates the opportunities and challenges posed by the development of a *global green growth program*: a worldwide program whose core is to invest between 1.5 percent to 2 percent of global GDP per year in raising energy efficiency standards and expanding the clean renewable energy supply. This could realistically within 20 years bring global emissions down by 40 percent relative to today while still supporting healthy economic growth rates. The paper analyses the industrial and financing policies that countries should implement to favour the development of energy efficient programs, and it shows how the green growth investments will create new opportunities for alternative ownership forms, including various combinations of smaller scale public, private and cooperative ownership. The paper highlights that, even though the energy efficient program will generate large scale increases in job opportunities, during the transition period, countries will have to implement policies to support workers and communities now depending on the fossil fuel industry.

The December 2015 UN-sponsored Paris Climate Agreement is a major milestone on behalf of the global project of climate stabilization. Coming out of the conference, all 196 countries have now formally recognized the grave dangers posed by climate change. Within their respective economies, they have all have committed to take action to substantially lower the greenhouse gas emissions that are causing climate change.

At the same time, taken together, these pledges are not close to being adequate to stabilize the climate at a global mean temperature at between 1.5 – 2ºC above pre-industrial levels no later than 2100—the goal that the Paris Agreement itself recognizes as necessary to achieve climate stabilization. Rather, according to the credible estimate by the environmental research NGO Climate Action Tracker, if all countries were to keep to the pledges they made at Paris, the global mean temperature would rise by between 2.4 – 2.7ºC by 2100.[1] In addition, even these inadequate pledges were not made legally binding in Paris.

The single most significant barrier to progress is straightforward: political leaders throughout the world simply do not want to make major cuts in their economies' consumption of oil, coal, and natural gas. Producing and consuming energy from these fossil fuel sources is responsible for generating about 74 percent of overall global greenhouse gas emissions. Carbon dioxide (CO_2) emissions from burning coal, oil and natural gas alone produces about 63 percent of all greenhouse gas emissions, while another 11 percent is caused mainly by methane leakages during extraction. Even putting aside the obvious self-interest and political power of both public and private fossil fuel companies, most political leaders remain convinced that significantly cutting fossil fuel dependency will slow economic growth and cost jobs—a price they are unwilling to pay.

Yet this premise is wrong. In fact, a worldwide program whose core is to invest between 1.5 – 2 percent of global GDP per year in raising energy efficiency standards and expanding clean renewable energy supply could realistically bring global emissions down by 40 percent relative to today within 20 years while still supporting healthy economic growth rates. Current global clean energy investments levels are at about $250 billion, 0.4 percent of global GDP. The consumption of oil, coal, and natural gas will also need to fall by about 35 percent over this same twenty-year period -- an average rate of decline of 2.2 percent per year.[2] Pursuing this investment pattern beyond this initial 20-year investment program could drive emissions down further, to the point where the global economy is capable of reaching a zero emissions standard probably within the next 50 – 60 years.

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1 http://climateactiontracker.org/global.html.

2 The background and model through which I generated these estimates are presented in my brief monograph *Greening the Global Economy (*MIT Press 2015). All additional references in this paper that do not have a specific citation within this article can be found in my book. Underlying the results in this book are two much more lengthy and detailed studies, Pollin et al. (2014) and Pollin et al. (2015).

These investments aimed at dramatically raising energy efficiency standards and expanding the supply of clean renewable energy sources—what we can term a *global green growth program*—will also generate tens of millions of new jobs in all regions of the world. This is because building a green economy requires hiring workers at a much greater rate than that needed to maintain the world's current fossil fuel-based energy infrastructure. At the same time, unavoidably, workers and communities whose livelihoods depend on the fossil fuel industry will lose out in the clean energy transition. Unless strong policies are advanced to support these workers, they will face layoffs, falling incomes, and declining public-sector budgets to support schools, health clinics, and public safety. It follows that the global green growth project must commit to providing generous transitional support for workers and communities tied to the fossil fuel industry.

How Green Growth Delivers Climate Stabilization

The World Resources Council recently reported that between 2000 and 2014, 21 countries, including Germany, Spain, Sweden the United Kingdom and the United States, all managed to "decouple" GDP growth from CO_2 emissions—i.e., GDP in these countries expanded over this 14-year period while CO_2 emissions fell.[3] This is certainly a favourable development. But the critical question remains: how significant is it relative to what is necessary to put the global economy on a successful path to climate stabilization?

As of the most recent worldwide data (2012), global CO_2 emissions are at around 32 billion tons per year.[4] The Intergovernmental Panel on Climate Change (IPCC) provides conservative benchmarks as to what is required to stabilize the average global temperature at no more than 2º Celsius (3.6 degrees Fahrenheit) above the pre-industrial average. The IPCC presents these benchmarks in terms of ranges and probabilities, but a fair summary of their two most recent assessments—i.e. their *Fourth* and *Fifth Assessment Reports*, published in 2007 and 2014 respectively—is that global CO_2 emissions need to fall by about 40 percent within 20 years, to 20 billion tons per year, and by 80 percent as of 2050, to 7 billion tons.

The global economy is not close to being on track to meet these goals. Overall global emissions rose by 33 percent between 2000 and 2012, from 24 to 32 billion tons, even with the 21 countries having

3 www.wri.org/blog/2016/04/roads-decoupling-21-countries-are-reducing-carbon-emissions-while-growing-gdp.

4 www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8.

successfully decoupled over this period.[5] CO_2 emissions rise for the simple reason that economies throughout the world continue to burn increasing amounts of oil, coal, and natural gas to produce energy. Correspondingly, the only way to achieve the IPCC emissions reduction targets is to dramatically reduce dependency throughout the world on fossil fuel energy sources.

There are large differences in the emissions levels resulting through burning oil, coal, and natural gas respectively, with natural gas generating about 40 percent fewer emissions for a given amount of energy produced than coal and 15 percent less than oil. It is therefore widely argued that natural gas can be a "bridge fuel" to a clean energy future, through switching from coal to natural gas to produce electricity. But such claims do not withstand scrutiny. At best, an implausibly large 50 percent global fuel switch to natural gas would reduce emissions by only 8 percent.[6] But even this calculation does not take account of the leakage of methane gas into the atmosphere that results through extracting natural gas through fracking. Recent research finds that when more than about 5 percent of the gas extracted leaks into the atmosphere through fracking, the impact eliminates any environmental benefit from burning natural gas relative to coal. One study focused on fracking projects in Texas and North Dakota in the U.S. found leakage rates in the range of 9 – 10 percent. If leakages continued at such rates, as would be likely if global fracking operations expanded, the overall emissions impact for natural gas would be worse than burning coal.[7]

Some analysts also consider "clean energy" to include nuclear power and carbon capture and sequestration (CCS) technologies. Nuclear power does generate electricity without producing CO_2 emissions. But it 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.[8] Similarly CCS presents 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 will, in any case, only increase to the extent that CCS technologies are commercialized.[9] As such, the most cautious program for clean energy demands investments in technologies that are well studied, already improving rapidly, and will not pose significant public safety and environmental problems.

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5 www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8.

6 See Pollin et al. (2015a, pp. 59 -60).

7 See Jackson et al. (2011, 2013).

8 See, e.g. Miller and Sagan (2009) and Takenaka and Topham (2013).

9 See Romm (2008).

The first critical project within the global green growth project is to dramatically raise energy efficiency levels. Energy efficiency entails using less energy to achieve the same, or even higher, levels of energy services from the adoption of improved technologies and practices. Examples include insulating buildings much more effectively to stabilize inside temperatures; driving more fuel-efficient cars or, better yet, relying increasingly on well-functioning public transportation systems; and reducing the amount of energy that is wasted both through generating and transmitting electricity and through operating industrial machinery.

Expanding energy efficiency investments support healthy economic growth because raising energy efficiency standards, by definition, saves money for energy consumers. A major 2010 study by the U.S. Academy of Sciences found, for the U.S. economy, that "energy efficient technologies…exist today, or are expected to be developed in the normal course of business, that could potentially save 30 percent of the energy used in the U.S. economy while also saving money."[10] Similarly, a McKinsey and Company study focused on developing countries found that, using existing technologies only, energy efficiency investments could generate savings in energy costs in the range of 10 percent of total GDP, for all low- and middle-income countries.[11] In her 2015 book, *Energy Revolution*, the Harvard University physicist Mara Prentiss argues, further, that such estimates understate the realistic savings potential of energy efficiency investments.

As for renewable energy, the International Renewable Energy Agency estimated in 2012 that, in all regions of the world, average costs of generating electricity with most clean, renewable energy sources -- wind, hydro, geothermal, and low-emissions bioenergy -- are now roughly at parity with fossil fuels (IRENA 2012). This is without even factoring in the environmental costs of burning oil, coal and natural gas, whose cost would of course rise through a carbon tax or cap. Solar energy costs remain higher, but they have fallen by 80 percent between 2007 and 2013, according to *Bloomberg New Energy Finance*.[12] They are likely to reach cost parity with fossil fuels in less than a decade.

Countries at all levels of development will also experience significant gains in job creation through clean energy investments relative to maintaining their existing fossil fuel infrastructure. Research that I have conducted with co-authors has found this relationship to hold in Brazil, China, Germany, India, Indonesia, South Africa, South Korea, Spain and the United States. With India, for example, we found that increasing clean energy investments by 1.5 percent of GDP every year for 20 years will generate a net increase of about 10 million jobs per year. This is *after* factoring in job losses resulting

10 www.nap.edu/catalog/12621/real-prospects-for-energy-efficiency-in-the-united-states.

11 file:///C:/Users/rpollin/Downloads/A_Compelling_Global_Resource.pdf.

12 http://about.bnef.com/services/renewable-energy/.

from retrenchments in the country's fossil fuel industries. Meanwhile, India's CO_2 emissions could be stabilized at their current low level and GDP would grow at an average of 6 percent per year.[13]

A Green Growth Policy Agenda

INDUSTRIAL POLICIES

In all countries throughout the world, effective industrial policies will be necessary to achieve a successful clean energy transformation. Depending on specific conditions within each country, industrial policies will be needed to promote technical innovations and, even more broadly, adaptations of existing clean energy technologies. Again depending on circumstances, governments will need to deploy a combination of industrial policy instruments, including research and development support, preferential tax treatment for clean energy investments, preferential financing arrangements, and government procurement policies. Clean energy industrial policies will also need to include regulations of both fossil fuel and clean energy prices as well as emission standards.

One major policy intervention that can facilitate the creation of a vibrant domestic market for clean energy will be for governments to themselves become both large-scale investors in energy efficiency and purchasers of clean renewable energy. One important comparable historical experience was the development of the internet within the U.S. military, beginning in the 1940s. In the process of bringing the internet to commercial scale, the U.S. military provided a guaranteed market for thirty-five years, which enabled the technology to incubate while private investors gradually developed effective commercialization strategies.[14] In the U.S. today, the military is playing a somewhat comparable role with respect to clean energy technologies. It has committed that 25 percent of all of its energy purchases will come from renewable sources by 2025.[15] To the extent that all government agencies, in the United States and elsewhere, make similar commitments, this will lead to major expansions in clean energy production, which in turn will accelerate technical innovations and increase opportunities in the private energy markets.

But guaranteeing stable prices with the private-sector purchases of clean renewables is also critical here. Such policies are termed *feed-in tariffs*. Specifically, these are contracts that require utility companies to purchase electricity from private renewable energy generators at prices fixed by long-term contracts. Feed-in tariffs were first implemented in the United States in the 1970s, and a

13 www.epw.in/system/files/pdf/2015_50/42/An_Egalitarian_Green_Growth_Programme_for_India.pdf.

14 See Ruttan (2006).

15 See Pollin et al. (2014), Ch. 8.

number of state and local programs are currently operational in the United States today. However, the impact of feed-in tariffs has been much more significant outside of the United States, especially in Germany, Spain, and Canada. A 2009 study by the U.S. Department of Energy found that these policies in Europe have "resulted in quick and substantial renewable energy capacity expansion."[16] The key factor in the success of these European programs is straightforward: the guaranteed prices for renewable energy have been set to adequately reflect the costs of producing the energy along with a profit for the energy provider. This then encourages private renewable energy investors by providing a stable long-term market environment.

A third critical industrial policy measure would be to price carbon emissions, which can be accomplished either through either a carbon tax or carbon cap. A carbon cap establishes a firm limit on the allowable level of emissions for major polluting entities, such as utilities. Such measures will also raise the prices of oil, coal, and natural gas by limiting their supply. A carbon tax, on the other hand, would raise fossil fuel prices directly. Either approach can be effective as long as the cap is strict enough, or tax rate high enough, to significantly reduce fossil fuel consumption and as long as there are few exemptions to the law. Raising the prices for fossil fuels will also, of course, create increased incentives for both energy efficiency and clean renewable investments.

Establishing what the impact is likely to be of a carbon cap or tax would of course first depend on the level of the cap or tax—i.e. at what price is carbon being priced, either through the cap or tax? The impact of a given carbon price will also vary by fossil fuel type, since the carbon content of oil, coal and natural gas varies. In addition, the market price of oil, coal and natural gas varies according to the costs of producing a given amount of energy from each fuel type, with oil being the most expensive and coal the cheapest per unit of energy. Finally, the impact of the tax or cap will depend on what the given market price is at any point in time. Considering these factors, using a simple mark-up approach to estimating such price effects, Pollin et al. (2015, pp. 72 -73) show that, with a $75 per ton carbon price, the mark ups would range between about 20 percent for crude oil, 64 percent for natural gas, and 250 percent for coal, based on mid-range assumptions as to the market price of these energy sources.

The additional factor that will affect the impact of a cap or tax will be fact that the market price of fossil fuel energy will of course vary over time. Given this factor, one consideration in designing the tax or cap is to allow for a variable carbon price. Under this type of arrangement, the carbon price could be set higher when the market price of fossil fuels is relatively low. The carbon price could then be allowed to decline when the market prices are high. Through this design feature, the carbon price would not create an excessive burden on energy consumers when market prices are spiking.

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[16] Cory, Couture, and Kreycik 2009, p. 2.

One must also be mindful of distributional effects in designing a carbon cap or tax. All else equal, increasing the price of fossil fuels would affect lower-income households more than affluent households, since gasoline, home-heating fuels, and electricity absorb a higher share of lower-income households' consumption. An effective solution to this problem is a so-called cap-and-dividend policy, developed by James Boyce. This approach would limit emissions by requiring large fossil fuel consumers to purchase emission permits. Auctioning the permits would drive dividends back into households, offsetting the higher cost of energy.[17]

PROVIDING CHEAP AND ACCESSIBLE FINANCING

Financing policies will play a major role in supporting large-scale clean energy investments in all country settings. The case of Germany is instructive, since it has been the most successful large advanced economy to date in developing its clean energy economy. The German government's financing policies have been critical, for example, to its success in implementing high efficiency standards. The overview of the International Energy Agency's 2013 *Energy Efficiency Market Report* focuses precisely on this point, as follows:

> Germany is a world leader in energy efficiency. Germany's state-owned development bank, KfW, plays a crucial role by providing loans and subsidies for investment in energy efficiency measures in buildings and industry, which have leveraged significant private funds (IEA 2013b, p. 149).

Clean energy financing policies have been equally important for developing countries and need to become even more so moving forward. The 2008 World Bank study *Financing Energy Efficiency: Lessons from Brazil, China, India and Beyond* describes 10 case studies of alternative energy efficiency financing structures that are achieving positive results.[18] These include a loan guarantee program for private energy efficiency financing in China, which began in 2003, the development of the Indian Renewable Energy Development Agency to provide subsidized loans for both renewable and energy efficiency investments, and Brazil's public benefit "wire-charge" mechanism, through which 1 percent of annual utility net revenues are utilized for renewable and energy efficiency investments.

Spratt, Griffith-Jones, and Ocampo emphasize a further major issue with respect to financing clean energy projects in low-income countries in their 2013 study *Mobilizing Investment for Inclusive Green Growth in Low-Income Countries*—that the benefits of clean energy investments be shared at

[17] See Boyce and Riddle (2011).

[18] Taylor et al. (2008).

least equally by the society's least advantaged groups. This would mean, as important examples, expanding access to electricity and providing clean energy for electricity and other needs at affordable prices. To accomplish these ends, Spratt et al. emphasize that it is not realistic to expect clean energy investments to consistently generate big profits for private businesses. The requirement that the financing terms for clean energy investments be affordable for borrowers—that is, not always yielding high returns for lenders—suggests a major role for public investment banks, including global institutions such as the World Bank, regional institutions, such as African Development Bank, and country-based development banking institutions.

Especially with public development banks, including the global multilateral development banks, playing a leading role, financing a net increase in clean energy investments at the level of about 1.5 percent of global GDP is a realistic goal. For 2015, as mentioned above, global clean energy investments were at around $250 billion, equal to about 0.4 percent of global GDP. This is while new capital expenditures in fossil fuels have fallen sharply in recent years, to around $125 billion per year between 2012 – 2015.[19] The International Energy Agency projects that this divergence—between growing clean energy investments while fossil fuel investments decline—will become still stronger through 2040. The IEA forecasts overall energy investments at around 2 percent of global GDP between 2015 – 2040, with renewable and efficiency investments becoming increasingly dominant over this 25-year period, especially in electricity generation (IEA 2015, pp. 92-93).

Still more broadly, overall global capital expenditures as a share of global GDP in 2014 were at a near 35-year trough, at 22 percent. This is down from 26 percent in 1989 and 24 percent in 2007, just prior to the Great Recession. The average global investment/GDP ratio between 1970 – 2014 is around 25 percent.[20] Within the context of these figures, raising overall global investments by 1-2 percentage points of GDP via expanding clean energy investments is certainly realistic. This is because, all else equal, the additional 1-2 percentage points of global GDP being provided by clean energy investments would, at most, only bring overall global investment to a level closer to the 25 percent average investment/GDP figure that has prevailed from 1970 – 2014.

Prospects for Alternative Ownership Forms

Beyond the need for public development banking, the difficulty of meeting the high profit requirements of large private corporations raises the question: how might alternative ownership

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19 See Randall (2016), http://www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels.

20 http://data.worldbank.org/indicator/NE.GDI.TOTL.ZS?end=2014&start=1970&view=chart.

forms—including public ownership, community ownership, and small-scale private companies—play a major role in advancing the clean energy investment agenda?

Throughout the world, the energy sector has long operated under a variety of ownership structures, including public/municipal ownership, and various forms of private cooperative ownership in addition to private corporations. Indeed, in the oil and natural gas industry, publicly owned national companies control approximately 90 percent of the world's reserves and 75 percent of production. They also control many of the oil and gas infrastructure systems. These national corporations include Saudi Aramco, Gazprom in Russia, China National Petroleum Corporation, the National Iranian Oil Company, Petroleos de Venezuela, Petrobras in Brazil, and Petronas in Malaysia. But there is no evidence to suggest that these publicly owned fossil fuel based energy companies are likely to be more supportive of a clean energy transition than are the private energy corporations. National development projects, lucrative careers and political power all depend on continuing the flow of large fossil fuel revenues.

Green growth investments will nevertheless create major new opportunities for alternative ownership forms, including various combinations of smaller-scale public, private and cooperative ownership. For example, community-based wind farms have been highly successful for nearly two decades in Germany, Denmark, Sweden, and the United Kingdom. A major reason for their success is that they operate with lower profit requirements than big private corporations.[21]

Falling costs for clean renewable energy, solar in particular, is also opening major opportunities for people to install and operate their own small-scale "distributed energy" systems that rely less and less on electrical grids. In January 2015, the *Financial Times* reported that "across the U.S., about 45,300 businesses and 596,000 homes have solar panels. . . . Over the past four years, the numbers have risen threefold for businesses and fourfold for homes, as the costs of solar power have plunged." The prospects for distributed energy are still greater in developing countries such as India, where over 40 percent of rural households do not have access to grid-based electricity. Distributed renewable energy will enable rural communities to leapfrog over grid-based systems entirely, just as mobile phone technology has enabled them stop depending on corporate-controlled landline phone companies.

[21] See Bollinger (2001, 2005) and Li et al. (2013).

Imports, Exports and the "Resource Curse"[22]

Within the global green growth project, large-scale transitions out of fossil fuel energy and into clean energy investments will need to take place in all countries, regardless of whether a country relies mainly on its own domestic resources or on imports for its fossil fuel supplies. Across the board, there will be far less demand for businesses throughout the fossil fuel supply chain—including transporting, refining, and distributing fossil fuels, both at the wholesale and retail levels. Workers and communities that are presently dependent on the fossil fuel industry will need to receive generous and effective transitional support.

But there will also be major differences in the difficulties faced by various countries, in particular between countries that are currently fossil fuel producers and exporters versus those that rely mainly on imports. Consider, for example, the case of Spain, in which annual fossil fuel energy imports amount to about 4 percent of GDP. Spain will enjoy a major increase in job creation through clean energy investments without experiencing large job losses as their domestic fossil fuel industry contracts. In addition, the fact that Spain will spend less on fossil fuel imports will free up a large new source of domestic funding to help finance the country's clean energy investment projects. Spain will also benefit because, at present, it faces a significant balance of payments constraint whenever its economy begins to expand. Reducing the economy's imported oil dependency will therefore also relax this balance-of-payments constraint on growth.[23]

Countries that export fossil fuels will face greater challenges, starting with the loss of their export revenues. However, many countries have already successfully navigated similar transitions. For example, Indonesia had long been a major exporter of both oil and coal before its oil exports began to fall substantially in the 1990s. In 2003, Indonesia began importing more oil than it exports, and in 2009, it suspended its membership in the Oil Producing Exporting Countries (OPEC). Indonesia did still continue to be a large-scale exporter of coal. Nevertheless, its overall fossil fuel export revenues—including sales of both oil and coal exports—fell by 35 percent as a share of GDP between 2001 and 2010. Despite this, Indonesia's overall GDP still grew at generally healthy rates.

All else equal, the Indonesian economy would almost certainly benefit from exporting larger amounts of both oil and coal. But the fact that the decline in Indonesia's fossil fuel exports did not

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22 This section follows closely from Pollin et al. (2015), pp 120-121, and Pollin et al (2015c).

23 In Pollin et al. (2015b), we discuss in depth the major advantages Spain can achieve through reducing its oil import dependency, especially as the country attempts to work its way out of the severe recession and austerity conditions that have prevailed there since the 2007-09 global financial collapse.

correspond with a similar decline in its overall GDP growth means that the country has demonstrated its capacity to adjust to the fall in its oil exports.

Indonesia's experience also raises an important broader question. Do countries endowed with large-scale fossil fuel resources necessarily end up better off than resource-poor countries? Or, alternatively, are countries with rich endowments of fossil fuel resources faced with the "resource curse?" The cause of the resource curse is straightforward: various groups within resource-rich economies will devote excessive amounts of time and effort to rent-seeking, as opposed to focusing on developing well-functioning economies. As an example, this pattern helps to explain why the nine countries in Sub-Saharan Africa that have been oil exporters for several years—Angola, Cameroon, Chad, the Republic of Congo, Ivory Coast, Equatorial Guinea, Gabon, and Nigeria—have not, in general, performed better than the rest of the continent in expanding economic well-being and reducing poverty.[24]

The Management of "Stranded" Fossil Fuel Assets

The fact that fossil fuel exporting countries should, in general, be able to adjust to a decline in their export earnings—as was the case with Indonesia—does not gainsay the fact that the global green growth project will entail major losses to fossil fuel corporations. Profits will fall permanently for the major companies, such as Exxon-Mobil and Shell. The world's publicly-owned energy companies—such as Saudi Aramco, Gazprom in Russia and Petrobras in Brazil, which together control about 90 percent of the world's total oil reserves—will experience still larger declines in their revenues. One should anticipate that all of these entities will continue to operate in their own self-interest. That will mean that they will be the major global and political forces acting to resist a global clean energy transformation.[25]

At the same time, it is important not to overstate the scale of the losses that fossil fuel companies are likely to face through a global green growth project. A 2013 study published jointly by Carbon Tracker and the Grantham Institute on Climate Change and the Environment at the London School of Economics examined the current holdings of the largest 200 private-sector fossil fuel companies, as listed in the world's various stock exchanges. This study estimated that "60–80 percent of coal, oil, and gas reserves of [these] firms are unburnable." From these figures, we can roughly estimate

[24] See Yates (2009) and references cited therein.

[25] Recent discussions on form such resistance has taken include Oreskes and Conway (2010), Cardwell (2014) and Diggs (2016).

that these companies are facing around $3 trillion in lost value over the next twenty years, and the certainty of further subsequent declines.

Of course, $3 trillion is a huge amount of money. At the same time, $3 trillion is also equal to only about 1.3 percent of the $225 trillion in total worldwide private financial assets as of 2012. Still more, the $3 trillion in losses that the fossil fuel corporations will face will not happen in one fell swoop. The declines will rather be incremental over a twenty-year period. On average, this amounts to asset losses of $150 billion per year. By contrast, as a result of the U.S. housing bubble and subsequent financial collapse in 2007–09, U.S. homeowners lost $16 trillion in asset values in 2008 alone—about 100 times the annual losses fossil fuel companies would face.

The fact that the decline in fossil fuel asset values will occur incrementally over decades also means that investors will have ample opportunity to diversify their holdings. Many are already doing so. As one important example, in June 2014 Warren Buffet, the best-known corporate investor in the world, announced that his company Berkshire Hathaway was doubling its holdings in solar and wind energy companies to $30 billion. This is even while Berkshire continues to own major shares of conventional utility companies. More generally, any rational fossil fuel company or asset owner should be making long-term adjustments in their investment strategies and portfolios, in the manner of Buffett. As they do so, the resistance to the global green growth project should correspondingly diminish with time. As discussed above, the global level of investment in clean energy over 2012 – 2015 was already roughly twice as large as that for fossil fuels.

Just Transition for Fossil Fuel Sector Workers

There is no denying that workers and communities throughout the world whose livelihoods depend on people consuming oil, coal, and natural gas will lose out in the clean energy transition. In order for the global clean energy project to succeed, it must provide adequate transitional support for these workers and communities.

The United Nations Environmental Program (UNEP) addressed this issue in a 2008 study, *Green Jobs: Toward Decent Work in a Sustainable, Low-Carbon World*. The authors describe what they term a “fair and just transition” for workers and communities that are currently dependent on the fossil fuel industries:

> The shift to a low carbon and sustainable society must be as equitable as possible… From the point of view of social solidarity, and in order to mobilize the political and workplace-based support for the changes that are needed, it is imperative that policies be put in place to ensure

that those who are likely to be negatively affected are protected through income support, retraining opportunities, relocation assistance and the like.[26]

Still, the impact on workers and communities from retrenchments in the fossil fuel sectors will not depend only on the level of support provided through explicit adjustment assistance programs, no matter how generous their provisions. The broader set of economic opportunities available to workers will also be critical. The fact that the clean energy investment project will itself generate a net expansion in employment in all regions of the globe means that there will be new opportunities for displaced fossil fuel sector workers within the energy industry itself. There will be more jobs for, among other occupations, operations managers, mechanical engineers, construction managers, farmers and ranchers, roofers, electricians, and sheet metal workers.

But further than this, the single best form of protection for displaced workers in all countries is an economy that operates at full employment. A full employment economy is simply one in which there is an abundance of decent jobs available for all people seeking work. In a full employment economy, the challenges faced by displaced workers—regardless of the reasons for their having become displaced—are greatly diminished simply because they should be able to find another decent job without excessive difficulties.[27]

Global Fairness

It is one thing to conclude that all countries—or at least those countries with either large GDPs or population—should invest about 1.5 percent of GDP per year in energy efficiency and clean renewable investments. But it is another matter to determine what standard of fairness should be applied in allocating the costs of such investments among the various people, countries, and regions of the globe. How should we allocate these costs fairly?

If the global green growth project sketched here is successful, average per capita CO_2 emissions will fall within twenty years from its current level of 4.6 tons to 2.3 tons, while total emissions will fall by approximately 40 percent, from 32 to 20 billion tons. Still, at the end of this 20-year investment cycle, average U.S. emissions will be 5.8 tons per capita, nearly three times the averages for China and the world as a whole, and five times the average for India. At a basic level, this does not seem

26 Renner et al. (2008) p. 27.

27 See, e.g., Ocampo and Sundaram (2008) and Pollin (2012).

fair. In particular because over the past century of the fossil fuel era, U.S. emissions have exceeded those in India and China combined by around 400 percent.[28]

In the name of fairness, one could, insist that the rich countries be required to bring down per capita CO_2 emissions to the same level as low-income countries. We could also insist that high-income people—regardless of their countries of residence—be permitted to generate no more CO_2 emissions than anyone else.

While there is a case for such measures, a broader view including political, efficiency and ethical elements can change the conclusion. First, from the political point of view, there is absolutely no chance that they will be implemented. Given the climate stabilization imperative facing the global economy, there is simply no cushion of time for investing huge global efforts fighting for unattainable goals. Focus for the moment on the U.S. case. On grounds of both ethics and realism, it will be much more constructive to require that, in addition to bringing its own emissions down to about 6 tons per capita within twenty years, the United States must also assist other countries to finance and bring to scale their own transformative clean energy projects.

The case of Indonesia is illustrative. In 2012, Indonesia's per capita GDP was around $3,500, which places it among the lower middle-income countries. Its per capita carbon emissions were roughly a tenth of those of the United States. But Indonesia aims to growth rapidly over the next twenty years, in the range of 6 to 7 percent annually. The Indonesian government also projects a more than five-fold increase in emissions over this twenty-year growth cycle, assuming growth is fuelled primarily by oil, coal, and natural gas.

If Indonesia and other emerging economies grow on the basis of a fossil-fuel dominated energy infrastructure, the chance of achieving the IPCC's global emissions reduction target would be close to zero. But if Indonesia invests about 1.5 percent of GDP in energy efficiency and clean renewables every year over the next 20 years, emissions per capita would stabilize at the country's current low level, even as the economy grows at around 6 percent per year. At the end of the 20-year investment cycle, employment throughout Indonesia's economy should also increase by roughly 1.8 million jobs relative to a trajectory in which fossil fuels remained the economy's dominant energy source. This net employment expansion would amount to about 1.3 percent of the economy's labour force.[29]

Overall then, in all regions throughout the global economy, the central elements of a viable global green growth program are straightforward. We start with investments in energy efficiency and clean renewable energy sources at roughly 1.5 percent of GDP per year. Each economy's fossil fuel sectors

28 http://cdiac.ornl.gov/trends/emis/tre_tp20.html#.

29 See Pollin et al. (2015a), pp. 207-11.

will need to contract as the demand for energy services is met through rising efficiency levels and affordable renewable energy. These energy efficiency and renewable energy investments will need to be nurtured by effective industrial policies as well as cheap and abundantly available financing. Further, as part of this overall global program, the high-income countries of the world will need to support the clean energy investment programs in developing economies. In all countries, these investments will open opportunities for alternative ownership forms, including various combinations of smaller-scale public, private and cooperative ownership. They will also generate large-scale increases in job opportunities, even after factoring in the job losses tied to fossil fuel industry retrenchments. Effective transition policies will nevertheless need to be advanced to support workers and communities now dependent on their countries' fossil fuel industries. With such policies in place, the global green growth project is capable of delivering both climate stabilization and substantial net gains in human well-being.

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