BEYOND 2015:
AN INNOVATION-BASED FRAMEWORK FOR GLOBAL CLIMATE POLICY

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EXECUTIVE SUMMARY

The world faces two contradictory energy challenges: mitigating climate change and expanding affordable energy access in low-income countries. Unfortunately, prevailing climate policies, including carbon caps and pricing, regulatory mandates, and subsidies to deploy existing high-cost technologies, have failed to effectively address either challenge. As a result, fossil fuel consumption continues to increase, and clean energy, while growing slowly in market share, remains a higher-priced, luxury good incapable of cost-effectively replacing fossil fuel energy.

International climate negotiations, set to conclude in Paris in 2015, are focused on how to integrate countries' past individual actions into a cohesive global agreement, but most of the policy proposals on the table mirror the unsuccessful approaches of the past 20 years. Rather than continuing down the same path, the 2015 negotiations offer an opportunity to craft a fundamentally new approach to decarbonizing the global energy market that prioritizes innovation to make clean energy cheaper than fossil fuels without subsidies. This will enable energy consumers in high-income nations to voluntarily switch to clean energy for economic reasons and consumers in low-income nations to more easily afford clean energy to address energy poverty. Most importantly, it offers the best opportunity to rapidly transition to a global clean energy economy.

Achieving this goal requires the international climate community to support a new framework for clean energy innovation policy based on the following principles:

- The paramount goal of climate policy should be to make the unsubsidized cost of clean energy cheaper than fossil fuels so that all countries deploy clean energy because it makes economic sense.
- Innovation of cheaper technologies, and not just deployment of existing high-priced technologies, is the fundamental way to achieve clean energy affordability.
- Countries have differentiated policy responsibilities in achieving this goal, depending on their level of development.
- Robust government support, including significant investment for clean energy research, development, and demonstration (RD&D), is necessary to make energy technologies cheaper than fossil fuels.
- Climate policy should provide emerging clean energy technologies niche market support to overcome inherent market barriers to commercialization through the use of smart innovation-driven deployment policies.
- Efforts to create large, global clean energy markets require strong policies that provide adequate incentives and intellectual property protection for companies and entrepreneurs developing clean energy innovations.
- Unfair clean energy market competition, including internationally sanctioned compulsory licensing, limits innovation.

- Climate policy should not force low-income countries to pay more for clean energy to provide much-needed energy access in the name of carbon mitigation.

The current approach to global climate policy is based on the notion that we can overcome climate change if all nations reduce carbon emissions by subsidizing the adoption of existing clean energy technologies. International climate negotiations principally aim to do so by getting all countries to commit to carbon reduction targets, even though such efforts have previously failed to curb emission growth. The principal approach advocated at the national level is to make dirty energy more expensive than clean energy through carbon caps or taxes, which have been met with political resistance to higher energy prices and have limited impacts without innovation.[1]

International institutions, like the World Bank, have sought to support modest clean energy adoption in developing nations by funding energy efficiency and renewable energy projects with no eye toward spurring innovation. And many emerging countries have primarily focused on competitively unfair green mercantilist policies, including discriminatory procurement and compulsory licensing, to build domestic industries—limiting global clean energy innovation in the process.

With the lion's share of national and international climate policy efforts focused on ways to prop up today's expensive technologies, there has been a declining interest in developing more competitive, next-generation clean energy. Overemphasis on targets, pricing, and deployment has left few resources to support a dedicated innovation strategy, including clean energy RD&D. Indeed, the world underinvests in clean energy RD&D by roughly $70 billion a year, which amounts to only 13 percent of what the world spends on global fossil fuel subsidies and 27.5 percent of what it invests in clean energy deployment.[2]

It is time to fundamentally reform existing international climate policies by orienting them more toward driving innovation and the development of clean energy technologies that stand a chance of displacing fossil fuels without the support of regulation and subsidies. This report proposes a set of policy reforms to turn today's limited climate approaches into high-impact clean energy innovation policies that give the world a fighting chance at addressing global climate change. When nations meet in Paris in 2015, negotiators should work to create a framework that allows and encourages nations to do the following:

- Instead of being presented with a "take it or leave it" option of signing on to an international agreement to limit carbon emissions, high-income and emerging countries should have the option to participate by committing to investing in clean energy RD&D at an agreed-upon share of GDP.

- High-income countries should adopt "revenue-raising" policies to support clean energy innovation, including implementing a modest carbon tax, increasing oil and gas drilling fees, and eliminating wasteful fossil fuel subsidies and use a portion of these revenues to support clean energy RD&D.

- Instead of simply subsidizing the deployment of existing, high cost clean energy technologies, high-income countries should implement "smart" subsidies that are contingent upon technology cost reduction and performance increases so that they support new technologies through commercial scale-up.

- The UN, the World Bank, and climate financing mechanisms like the Clean Technology Fund should redesign their investment portfolios to limit funding for deployment of existing clean

technologies and energy efficiency projects, and instead prioritize supporting transformational energy technologies with financing for large-scale demonstration and smart deployment projects.

- Although low-income countries often lack the resources and infrastructure to support early stage R&D, they should collaborate with high-income countries and international institutions, like the International Energy Agency, to support the testing and demonstration of next-generation technologies in instances where it may be more affordable than fossil fuels. Engaging low-income countries as "test beds" for advanced energy technologies strengthens the global energy innovation ecosystem while increasing energy access in energy-poor nations.

- In absence of unilateral action by mercantilist countries to limit green mercantilist policies, including tariffs, forced localization, discriminatory government procurement and compulsory licensing, high-income countries and international organizations should work cooperatively to limit these policies.

- International institutions, including the World Bank and the UN, should exclude compulsory licensing in future international climate agreements and immediately stop supporting energy projects that include compulsory licensing of domestic content requirements.

- The UN should redefine "modern energy access" to the equivalent of what high-income countries benefit from today, sending a signal that much more effort and innovation is needed to advance solutions for global energy poverty.

In short, the world needs to give up the limited approaches of the previous decades and adopt innovation-based solutions as quickly as possible. These proposed policies offer a new start in global climate policy for the long term, with the recognition that climate change is a technology problem requiring solutions that advance low-carbon technology options. With time running out, it is now or never to get serious about implementing an aggressive clean energy innovation policy.

INTRODUCTION

Climate change is a global problem requiring solutions that have a global impact. The majority of future greenhouse gas (GHG) emissions will come from low- and middle-income countries expanding in population and wealth, not from high-income countries where energy demand growth is mostly flat. If the world stands any chance of decarbonizing, clean energy technologies can no longer be a "luxury good" deployed in a happenstance way by a few high-income nations. Rather, clean energy needs to be a low-cost "commodity good" deployed on a massive scale in both high-income and low-income countries because it makes economic sense to do so.

Unfortunately, for the last two decades, international and national decision makers in high-income countries have pursued a set of policies (e.g., carbon emission targets, carbon pricing, subsides, and regulatory mandates) that have failed to make clean energy technologies cheaper than fossil fuels outside of niche markets and accounting for the costs of storage. The cost of transitioning to a world fully supported by renewable energy by 2030, assuming existing technologies, is as high as $100 trillion, or 8 percent of global GDP per year for the next 20 years.[3] Not even a nation as wealthy as the United States is remotely interested in doing this, even in the face of overwhelming evidence of the threat of global warming. As a result, global carbon emissions have grown faster since 2000 (2.2 percent per year) than from 1970 to 2000 (1.7 percent per year), and show no signs of stabilizing, much less dramatically falling.[4]

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To date, most nations have not been willing to pay the higher price of switching to clean energy, and when they do, policy support is limited to modest levels of deployment. Reflecting this reality, a new international framework is needed to spur nations and international institutions to invest more in clean energy research, development, and demonstration (RD&D), leverage deployment policies focused on driving innovation, and implement win-win trade policies toward a single goal: making clean energy affordable through innovation. This report identifies the limitations of current international climate change policies enacted or under negotiation, and proposes a set of principles to move beyond these conventions and advance an innovation-based approach to cutting emissions. It also proposes specific policy reforms for re-orienting global climate change policy toward spurring clean energy innovation to make clean energy affordable.

CHARACTERIZING THE GLOBAL ENERGY AND CLIMATE CHALLENGE

Carbon dioxide (CO_2), unlike other pollutants that have been successfully regulated by some governments, does not immediately and directly lead to the deterioration of human health. Nor do the emissions largely impact individual nations, as the impacts of climate change are global. As such, any effective solution has to be proportionally global in scope.

In addition, energy consumption (the largest source of CO_2 emissions) is a key enabler of economic activity. Consequently, public policies aimed at reducing the consumption of fossil fuels can have negative economic impacts if not designed appropriately. International climate policy needs to consider in its design the fundamental relationships between global climate change, energy access, and economic growth. The following section illustrates these linkages and their relevant policy implications.

Global Carbon Emissions Continue to Rise

The 2014 Intergovernmental Panel on Climate Change (IPCC) report states unequivocally that "human interference with the climate system is occurring, and climate change poses risks for human and natural systems."[5] Ending human interference with climate systems requires no less than replacing all fossil fuel use (coal, natural gas, and petroleum) with zero carbon-emitting energy, and implementing robust carbon-capture technologies.[6] But if there is one true indicator of the failure of global climate policy it is this: the carbon intensity of the global economy—or the amount of carbon emitted per unit of global GDP—has decreased less than 1 percent in the last two decades.[7] But because global GDP continues to rise, the world must lower global carbon intensity by much more than 1 percent. By 2040, global population is expected to grow by 28 percent and per capita income is expected to grow by 128 percent.[8] Cutting total carbon emissions by 80 percent by 2040 requires lowering global carbon intensity by 93 percent. As Figure 1 shows, aggregate global carbon emissions continue to rise and are projected to more than double between 2010 and 2040. These trends make attaining global carbon reductions even more difficult and frankly out of reach with conventional strategies.

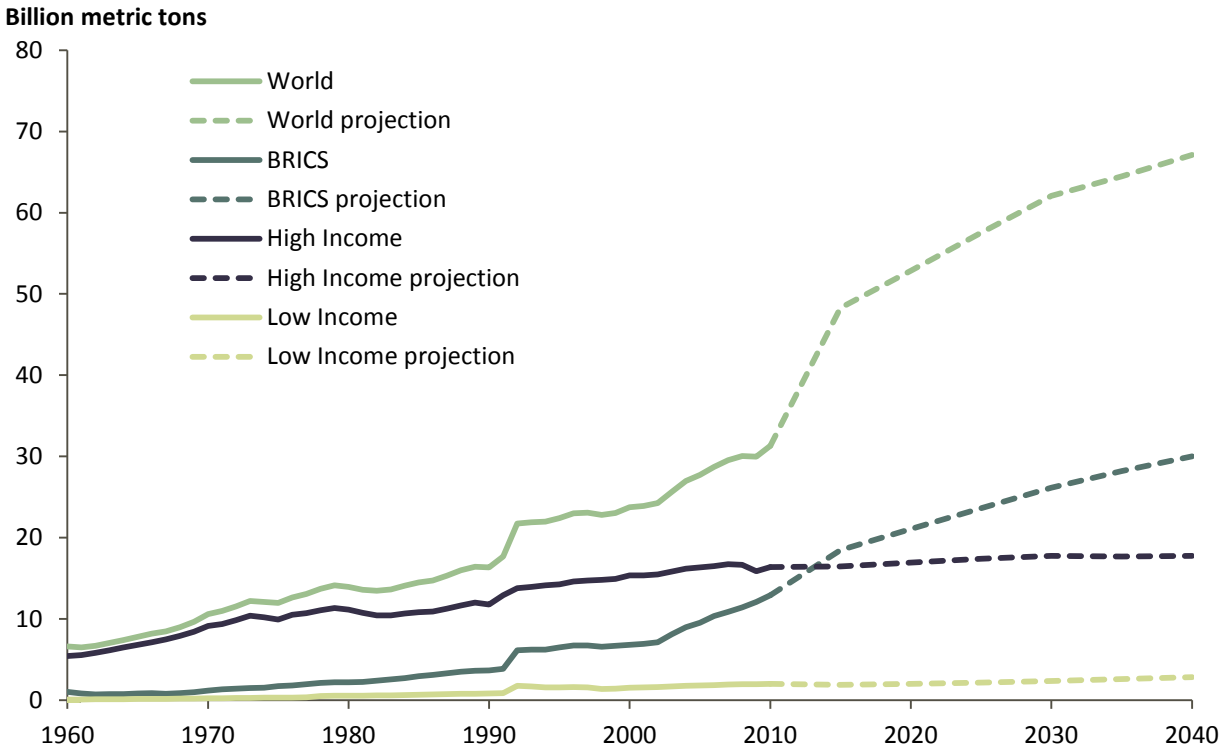

FIGURE 1: CO_2 emissions (in billions of metric tons) from 1960 to 2010, and projections to 2040. Historic trends data from World Bank; projections data from OECD and EIA.[9]

Global Energy Consumption Fuels Economic Growth

It is an established principle of global economic development that access to energy underpins economic growth and prosperity.[10] Figure 2 illustrates the relationship between per capita wealth and electricity consumption, indicating that people living in high-income countries generally consume more electric power than those in low-income countries. Historically, high-income countries (like the United States), especially ones in colder regions that rely on energy more often to heat buildings (like Canada, Finland, Iceland, and Sweden), have traditionally consumed more energy per capita than other nations.[11]

Unfortunately at least 80 percent of global energy consumption continues to be generated by burning coal, natural gas, and oil—the chief sources of carbon emissions.[12]

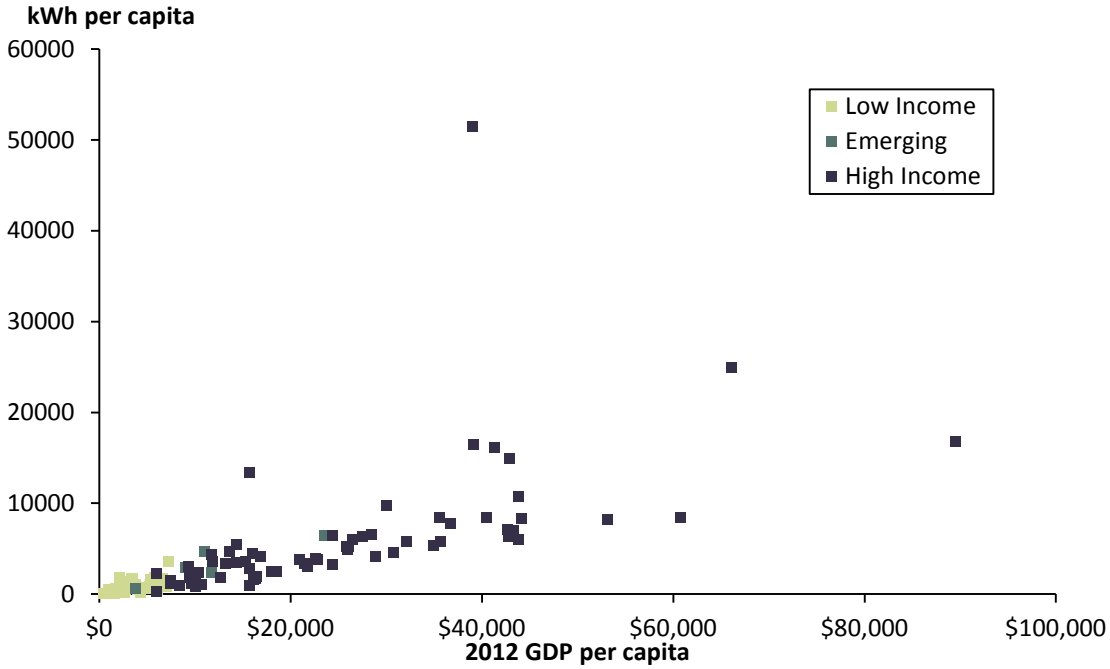

FIGURE 2: Electric power consumption (per kWh) per capita in relation to GDP per capita (PPP, Current international dollars), using World Bank data.

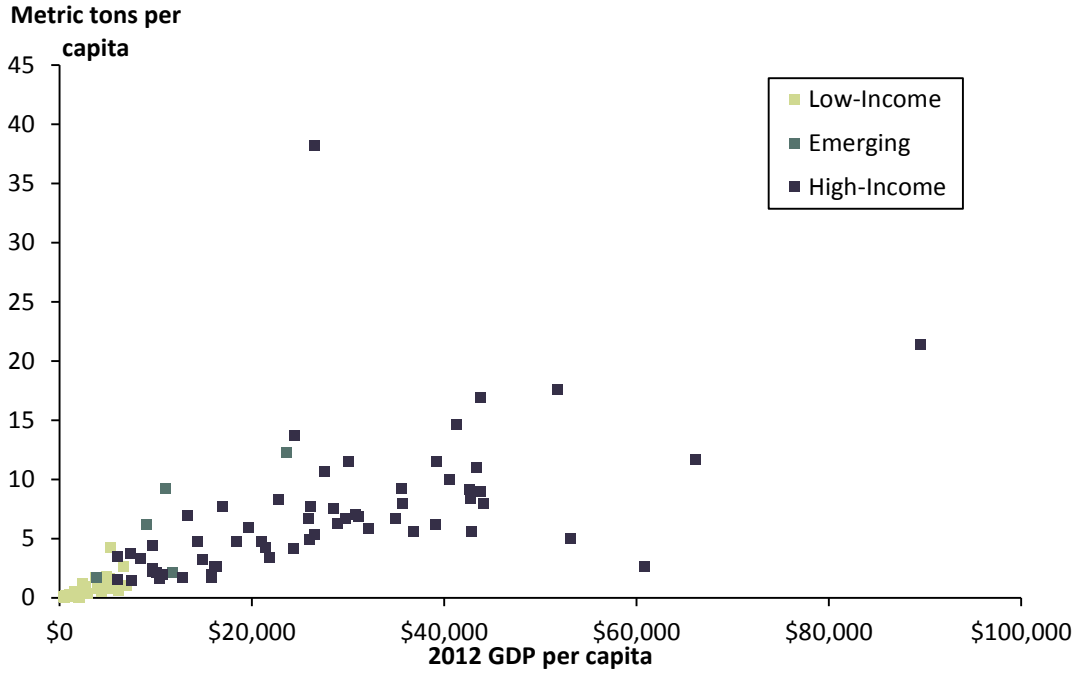

FIGURE 3: CO2 emissions per capita (2010) in relation to gross domestic product per capita (in PPP, current international dollars), using World Bank data.

In addition, emerging economies such as Brazil, Russia, India, China, and South Africa (referred to as the "BRICS"), are among the world's leading energy consumers as their populations expand and per-capita incomes increase. According to the Organization for Economic Co-operation and Development (OECD), BRICS' carbon emissions are projected to increase 85 percent by 2050.[13]

There may be no better example of the deep links between economic growth and carbon emissions than the Asian economic boom of recent decades. Since 1980, rapid economic growth in Asian countries has more than doubled global coal consumption.[14] China alone increased its coal consumption by over 400 percent and carbon emissions by 500 percent since 1980 to support an eight-fold increase in GDP per capita, bringing an estimated 672 million people out of poverty.[15] China's economic growth will likely be replicated in many poorer nations over the next half century (although not likely at the same rate).

No Nation Wants to Sacrifice Economic Growth for Climate Mitigation

China's growth and carbon emission trajectories underline an important point: increasing energy use is one of the most important indicators of economic development. While high-income countries can afford high levels of energy use, most low-income countries cannot. According to the International Energy Agency (IEA), approximately 1.3 billion people do not have access to electricity.[16] And even when households can afford electricity, some locations still lack a modern distribution system that would grant them access to it.[17]

Without access to electricity, economic growth opportunities are limited. A study of African electricity consumption found that while energy access is just one factor impacting economic growth, "poverty and poor access to modern energy are intractably linked."[18] Similar research has found that the same principle applies to some Asian countries.[19] A broader study of 25 OECD countries found that an increase in energy consumption leads to a subsequent increase in growth, although clearly the relationship is circular: more growth enables more energy consumption.[20]

Figure 4 illustrates the relationship between per capita income and access to electricity. Nearly all European countries and high-income nations like Australia, Canada, Japan and the United States have near-100 percent access to electricity. Countries with around 50 percent access are generally small Pacific Island, African, or Asian countries including Cameroon and Bangladesh, and the countries with the lowest percentage of access to electricity are primarily Sub-Saharan African countries. While some countries with low per capita income have high access to energy, very few countries with high per capita income have less than 90 percent access to energy.

The benefits of electricity access are significant, as they are not limited to one sector of the economy. Manufacturing, education, public health, and food security can all be improved with increased access to electricity, and these improvements can drastically drive developments in life expectancy, child mortality, and quality of life.[21] Energy access improves public security, public education, and rural economic activity, and improves services for women and children.[22]

Simply put, providing universal energy access is one of the defining global energy issues today. As the billions with little-to-no access to energy shift to greater use of electricity and transportation fuels, and while fossil fuels remain the most affordable energy option, global carbon emissions will increase.[23] Recent estimates suggest that carbon emissions from low-income and emerging countries will exceed those from high-income countries in the coming decades.[24]

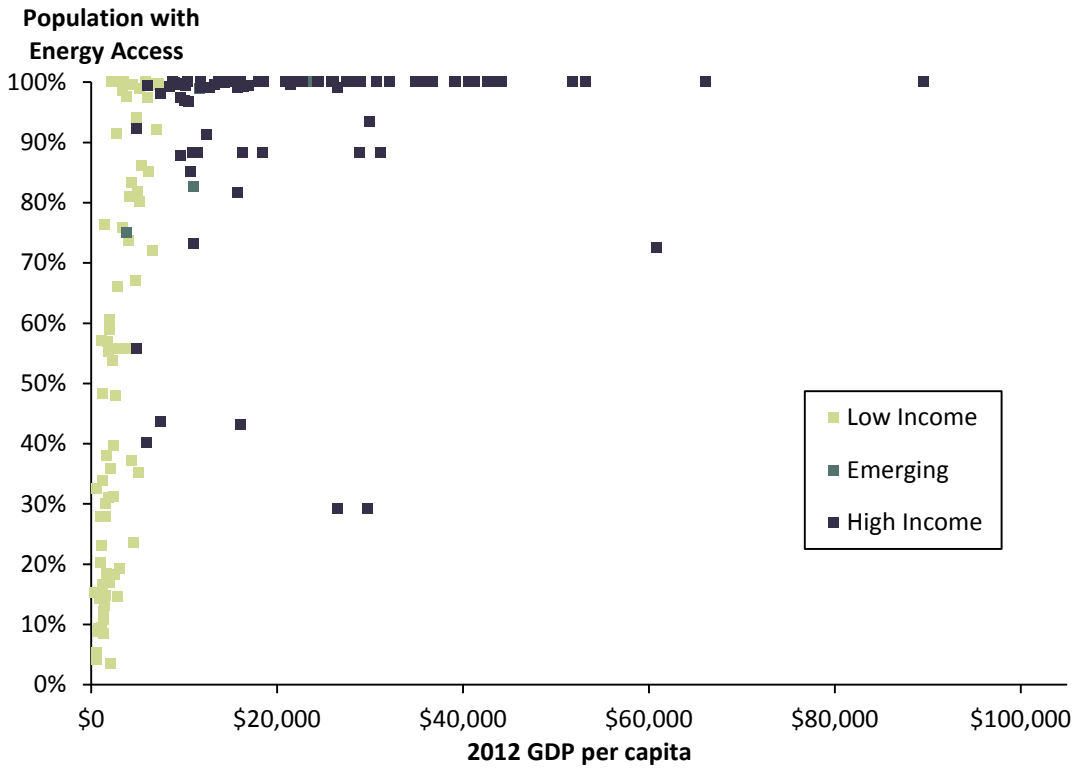

FIGURE 4: Access to energy (as a percent of total population) in relation to gross domestic product per capita (in current U.S. dollars), using data from the World Bank.

Thus, while spurring development in low-income nations and providing energy access should be a top global priority, doing so will lead to increased CO_2 emissions unless clean energy becomes cost and performance competitive with fossil fuels. There is simply no other way of addressing both access and climate change because the other options are unfair and even immoral. It is unreasonable and dissolute for the international community to withhold support for global energy access as a way to halt fossil fuel consumption and limit carbon emissions. Requiring low-income countries to limit growth or only buy more costly clean energy is not only unfair—it will do virtually nothing to address climate change. Only widespread clean energy adoption will do that, and that will not happen without widespread cost and performance competitiveness.

The Age of Fossil Fuels Will Not End Without Innovation

Solving global climate change is largely about solving one the great technological challenges of our time: making clean energy cheaper than fossil fuels. There is an old joke that the Stone Age did not end because humans ran out of stone. It ended because humans invented bronze. The same likely holds true with the fossil fuel age—it will not end when we run out of fossil fuels. It will end when we invent clean energy that is cheaper than fossil fuels.

Energy is a fungible good. From the consumer perspective (i.e., turning on the lights), electricity from low-carbon sources is no different from electricity from fossil fuels. Thus, price is the defining characteristic. And the critical reason the world has yet to reduce carbon emissions is because clean energy is not yet cost and performance competitive with fossil fuels, making the transition slow and difficult. To date, zero-carbon technologies are competitive only in niche markets or through the use of subsidies and mandates. Even in cases where wind and solar technologies are cost competitive, their penetration levels are limited

because those costs do not include the storage and integration technologies necessary for each to provide base load power at all times of the day. For example, an often-cited study on how the United States can deploy up to 80 percent renewable energy technologies estimated the need for 140 gigawatts (GW) of new utility scale energy storage and up to 48 GW of new load balancing by 2050.[25] Deploying the necessary storage and balancing technologies would be very expensive, and in many cases the technologies are not yet commercially available.

Outside of niche markets, making clean energy cheaper than fossil fuels without subsidies requires numerous technology advancements in addition to storage.[26] According to the IEA, "Promising renewable energy technologies (such as offshore wind and concentrating solar power) and capital-intensive technologies (such as carbon capture and integrated gasification combined cycle [IGCC]), have significant potential but still face technology and cost challenges, particularly in the demonstration phase."[27] Potsdam Institute energy specialist Brigitte Knopf argues in a new study that substantial technological progress across a range of energy technologies, like third-gen solar cells, nuclear fusion, and others, is needed to meet long-term climate goals affordably.[28] Next-generation nuclear energy (e.g., small modular reactors) requires materials innovation, advanced thermal reactor designs, supply-chain development, re-establishing a robust innovation and testing ecosystem, as well as new regulatory designs.[29]

Moreover, achieving the kinds of sustained, long-term, "Moore's Law" price declines needed to make wind, solar photovoltaics (PV), and batteries widespread and competitive in the long term will not likely come from just expanding their market sizes, any more than computer chip speeds have grown exponentially just from larger chip markets. More innovation to increase solar cell efficiencies, wind-energy conversion, and battery storage capacity is necessary.

Without these technological innovations, deeply cutting carbon emissions in the near term means exacerbating—not solving—the energy access and economic growth challenges described previously. University of Colorado Professor Roger Pielke Jr. argues that the intersection between growth and climate change is the quintessential "Iron Law of Climate Policy": efforts to reduce carbon emissions that also stifle economic growth are met with growing social and political resistance.[30] Since no country in the last century has been able to substantially increase energy access and reduce poverty without also substantially increasing its greenhouse gas emissions, one could make a case that any attempts to increase energy access while mitigating climate change offer similar opportunities for social and political resistance.[31]

> "Without technological innovation, cutting carbon emissions deeply in the near term means exacerbating—not solving—energy access and economic growth challenges."

Therefore, dramatically cutting carbon emissions with today's more expensive clean energy technologies is not feasible without dramatically increasing energy costs, which consumers in high-income countries are not willing to pay and consumers in low-income and emerging countries will not be able to pay. Spurring technological innovation to reduce costs and increase performance is the linchpin of solving the global climate-access-growth challenge.

WHY INTERNATIONAL CLIMATE POLICY HAS YET TO SUCCEED

Even though driving clean energy costs down through innovation is at the core of solving climate change as quickly as possible, the dominant climate policy approaches have largely missed this target, while many countries continue to implement green mercantilist policies and fossil fuel subsidies that actually harm the world's ability to reduce carbon emissions in the long term.

Carbon Targets Have Failed to Reduce Carbon Emissions

Since the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992, international climate policy has been driven by the belief that nations must commit to reducing greenhouse gases to address climate change.

The UNFCCC agreement called on countries to stabilize greenhouse gas concentrations at a "level that would prevent dangerous anthropogenic interference with the climate system" within a "time-frame sufficient to allow ecosystems to adapt naturally to climate change."[32] In 1995 countries convened to create a more detailed carbon target agreement, resulting in 1997's Kyoto Protocol which legally committed developed countries to reduce carbon emissions by 5 percent below 1990 levels over a five-year period.[33] It entered into force by 2008 due to a lag in countries' ratification, but it ultimately failed to meet its main objective: global carbon emissions increased by 7.5 percent from 2008 through 2012, when the first target period of the Protocol ended.[34] In fact, emission growth would have been higher if not for the severe global recession in 2008-2009 that reduced energy consumption.

The Kyoto Protocol failed for three main reasons. First, even though 191 countries joined the Protocol, the largest emitters were absent.[35] The United States (the largest emitter at the time) failed to ratify, Canada withdrew by 2011, and China and India were exempted from meeting the target because they were deemed "developing" countries.

Second, the Protocol failed to inspire nations to reduce emissions, even though they had agreed to carbon caps, because of the cost of clean energy. For instance, Japan announced that it had to renege on its carbon reduction commitment of 25 percent by 2020, due to the cost of transitioning some of its nuclear plants to coal, gas, and renewables in the aftermath of the 2011 earthquake and tsunami that led to the Fukushima Daiichi nuclear meltdown.[36] Even the European Union (EU)—a bulwark of climate policy—is struggling to create new carbon targets after the economic recession made it artificially easy to meet its original goal of 20 percent carbon cuts below 1990 levels by 2020.[37] It recently proposed a 2030 carbon reduction goal of 40 percent below 1990 levels. In response, the Bulgarian Economy and Energy Minister Dragomir Stoynev declared the EU energy policy "a total failure," because policymakers proposed carbon targets that "disagreed with the prospects of European industry."[38] The EU is hesitating to finalize the new targets, particularly because Eastern European countries are raising concerns over industrial competitiveness and energy costs.[39]

Third, even if all nations participated and succeeded in meeting their targets, the targets are not enough to adequately respond to climate change. Nations won't commit to more aggressive targets because the economic costs would be too significant. Indeed, as long as clean energy is more expensive than fossil fuels, even high-income countries are not willing to accept lower economic competitiveness and higher energy prices from significant adoption of clean energy. As a coalition of leading climate policy thinkers argued in *Climate Pragmatism: Innovation, Resilience and No Regrets*:

> The old climate framework has failed because it would have imposed substantial costs associated with climate mitigation policies on developed nations today in exchange for climate benefits far off in the future—benefits whose attributes, magnitude, timing, and distribution are not knowable with certainty. Since they risked slowing down economic growth in many emerging economies, efforts to extend the Kyoto-style framework to developing nations predictably failed as well.[40]

Nonetheless, the world continues to negotiate a new international carbon target agreement by 2015, though not without challenges. Negotiations did not succeed in Copenhagen in 2009, ultimately leading to countries agreeing to provide their specific emission reduction pledges through 2020 by the following year in Cancun.[41] For example, the United States voluntarily pledged to cut carbon emissions 17 percent below 2005 levels by 2020, while China voluntarily set carbon intensity (i.e., emissions as a share of GDP) targets of 40 percent to 45 percent below 2005 levels by 2020.[42] The European Union has committed to cutting emissions 20 percent below 1990 levels by 2020 and 80 percent to 95 percent by 2050.[43]

Even with these commitments, global carbon emissions are expected to increase by almost 10 percent from 2014 to 2020 at a time when the world needs to be bending the carbon curve down, not up.[44] Accounting for the voluntary carbon reduction pledges made in Cancun, the Intergovernmental Panel on Climate Change (IPCC) finds that they "are not consistent with cost-effective long-term mitigation trajectories that are at least as likely as not to limit temperature change to 2°C relative to pre-industrial levels, but they do not preclude the option to meet that goal."[45]

"Even with these commitments, global carbon emissions are expected to increase by almost 10 percent from 2014 to 2020 at a time when the world needs to be bending the carbon curve down, not up."

The main takeaway from nearly two decades of trying to forge a legally binding international carbon reduction target that cuts carbon emissions is that the time spent doing so often far outweighs the meager benefits. Efforts to forge a new agreement by 2015 seem destined for a similar fate. Carbon targets are of little use without national and international policies that develop affordable and viable low-carbon alternatives to fossil fuel consumption.

Carbon Pricing is Not a Panacea for Climate Policy

In any effort to control the level of output of a good or service, regulators can set its price or the quantity produced, but not both. Most environmentalists prefer regulating quantity through carbon caps (often with a trading component) because they believe it provides more certainty for reductions. For instance, the European Union, California, and a coalition of U.S. Northeastern states have implemented a cap and trade system to gradually limit the production of CO_2. But these caps have never been large enough to have a real impact because high caps would mean higher overall energy prices.

A growing number of advocates, economists, and policymakers prefer regulating price through a carbon tax because they believe it less distortionary than a cap and trade system.[46] But because the political resistance to high prices is usually strong, most carbon prices are quite modest. British Columbia implemented a $30 per metric ton of CO_2 carbon tax in 2008 that included a cut in income taxes to offset higher energy costs.[47] And Australia implemented a $23 per metric ton tax on 500 of the country's largest carbon emitters in 2012, annually indexed for inflation.

Both carbon caps and taxes end up raising the price of fossil fuels to account for externalities not included in its current cost to society, such as the impact of pollution. Neoclassical economic theory holds that with fossil fuels properly priced, existing clean energy technologies become more competitive and consumers are more willing to switch to low-carbon energy.[48] Some advocates go even further and argue that a carbon cap or tax will spur innovation to bring down the cost of clean energy. Technologist Ramez Naam argues that "carbon prices accelerate innovation that brings down the price of green energy."[49] Economist Paul Krugman stated that "once we get to the point where a carbon price makes [wind and solar technologies] commercially viable, there's every reason to expect huge improvements over time through, yes, the magic of the marketplace."[50] And prominent environmental economists Joseph Aldy and Robert Stavins write that carbon pricing can "deliver powerful innovation incentives."[51]

But whether it is implemented through a carbon tax or cap and trade system, relying principally on increasing the price of fossil fuels to drive the adoption of clean energy is a flawed climate policy tool for two reasons.

First, there is little political will to implement the high carbon prices needed to truly change the market. This is because absent innovation to lower the price of low-carbon energy, carbon pricing simply raises the price of energy writ large, which elicits political and consumer resistance.[52] High-income countries are constrained by unwillingness to pay higher energy prices or place limits on the economy.[53] And low-income countries are not economically able to bear the brunt of higher energy costs, particularly if they are trying to provide basic access to energy. In other words, the so-called "Iron Law of Climate Policy" holds true—consumers and industry in high-income countries may be willing to take on small costs for mitigating climate change, but anything higher is difficult to impose and low-income countries simply cannot.

As a result, the best countries can do is implement a low, politically acceptable, but ineffective carbon price within the range of what consumers are willing to pay. For instance, in early 2014, after significant price volatility, the EU's carbon trading price stood at a paltry $5 per metric ton of carbon, or the equivalent of increasing the price of a gallon of gasoline by roughly 5 cents—far too little to change the incentive structure of the energy market.[54] Yet, additional reforms are being considered to shield European industries from higher energy prices, even with such a low carbon price.[55] Likewise, California had to implement $1 billion worth of credits to consumers and utilities to blunt the "sticker shock" of higher energy bills.[56] The Regional Greenhouse Gas Initiative in the Northeastern United States trades at just $4 per metric ton of CO_2.[57] And when the United States attempted to create a similar nationwide cap and trade system, it failed to make it through Congress due to concerns that it would significantly raise energy prices.[58]

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Second, even if a carbon price were much higher, it would not likely spur much-needed innovation. A recent study on the sources of major technological advances of the last century—including agriculture mechanization, airplanes, automobiles, computing, dyestuffs, electrification, gas turbines, television, and wind power—found price signals played a minor role at best in their development. Rather, these

technologies emerged because of technology breakthroughs: technology push, not just technology pull, was the driver.[59]

We can see this playing out now in Europe, where the price of a gallon of gas is often double that of the United States—around eight dollars per gallon in Belgium, France, Germany, and the Netherlands, and closer to nine dollars in Italy—the equivalent of roughly a $500 per ton carbon price.[60] Yet this de facto carbon tax has done little to spur the adoption of electric vehicles or the development of better batteries. Instead, high gas prices have encouraged Europeans to drive less and use more fuel-efficient vehicles. This incentive is important for addressing and controlling environmental pollution, but it is unrealistic to think its effects will seriously mitigate climate change, given the fact that the developing world will add more cars and trucks than now exist in the developed world.[61] In fact, according to Argonne National Laboratory, China will have more than half a billion more cars on the road by 2050 than it does today.[62] Whether or not these cars get 20 miles or 40 miles to the gallon does not really matter in solving climate change. While more fuel-efficient vehicles have other environmental benefits, such as reduced air pollution, the world needs near-zero emissions from the global transportation sector to mitigate climate change.[63]

Carbon prices induce some incremental innovation, but mainly they spur the adoption of the cheapest existing technologies that are already commercially available. For example, the most-cited academic case study on the impact of higher energy prices on the development of energy efficient appliances that carbon price advocates point to in support of price signals inducing innovation actually proves its limited impacts.[64] Adopting more efficient appliances over the next 40 years will not solve climate change—only powering these appliances with low-cost renewable energy will, and that requires innovation. In other words, policymakers and climate advocates need to realistically assess the limits of carbon pricing as a core climate strategy.

Countries Continue to Subsidize Fossil Fuel Technologies

Even as countries attempt to reduce global carbon emissions, many countries continue to subsidize the production and consumption of fossil fuels. The International Monetary Fund (IMF) calculates that global fossil fuel subsidies reached nearly $500 billion in 2011 (0.7 percent of global GDP), and IEA estimates that number rose to $544 billion in 2012.[65] Studies that include estimates of the negative externalities associated with fossil fuel consumption evaluate the cost of subsidies to be much higher, at $1.9 trillion (2.5 percent of global GDP) per year.[66] While policymakers in support of maintaining subsidies argue that they are necessary for price stabilization and economic security, recent studies show that fossil fuel subsidies are largely unproductive, regressive, and costly to governments in both high-income and low-income economies.[67]

"The International Monetary Fund (IMF) calculates that global fossil fuel subsidies reached nearly $500 billion in 2011 (0.7 percent of global GDP), and IEA estimates that number rose to $544 billion in 2012."

Fossil fuel subsidies artificially undervalue the cost of energy, impede investment in clean energy technologies, and support inefficient overconsumption of fossil fuels.[68] For example, although oil and gas prices are high enough that the fossil fuel industry turns a significant profit and are more than capable of investing in future growth, the U.S. fossil fuel industry received at least $4.2 billion in industry-specific tax credits in 2013, and the level of policy support is magnitudes higher.[69]

Although subsidies are usually promoted as a mechanism for increasing economic growth and energy access, the Global Subsidies Initiative found that they often adversely impact inequality by benefitting higher-income groups with higher energy consumption patterns.[70] An IMF study confirmed this association, concluding that "the richest 20 percent of households in low and middle income countries capture six times more in total fuel product subsidies than the poorest 20 percent of households," which capture only 7 percent of the benefit.[71] The expense to national governments to maintain these subsidies is often substantial and difficult to sustain in the long term.[72]

Motivated by a mounting recognition of global fossil fuel subsidies as a persistent and growing problem, the G20 countries have committed to phasing out inefficient fossil fuel subsidies that "encourage wasteful consumption" by 2020.[73] But unfortunately the transition off of subsidies is not easy. Some countries—Iran in 2007, Nigeria in 2012, and Indonesia and Malaysia in 2013, among others—have already moved to cut fossil fuel subsidies to reduce government budget costs, and in these cases the reforms increased gas prices by as much as 50 percent and consequentially were met with riots and political protest.[74] The IMF and other international organizations are taking an important next step in the debate to compile case studies of successful reform policies and to develop strategic recommendations for cutting fossil fuel subsidies without adversely affecting low-income groups. Suggestions include extensive consultation with stakeholders, sequenced price increases by sector, establishment of transfer payment programs, and investment in clean energy.[75]

High-Income Countries are Choosing Deployment Over Clean Energy Innovation

While carbon pricing and caps have dominated the international climate policy debate, many countries have also spent significant public dollars on clean energy. But rather than designing and supporting a clean energy innovation strategy, the majority of public spending has gone toward subsidizing the deployment of current-generation technologies. This "deployment consensus" approach to clean energy policy has provided a short-term boost in deployment at the expense of long-term innovation and cost competitiveness.[76]

"Rather than designing and supporting a clean energy innovation strategy, the majority of public spending has gone toward subsidizing the deployment of current-generation technologies. This "deployment consensus" approach to clean energy policy has provided a short-term boost in deployment at the expense of long-term innovation and cost competitiveness."

Governments have an important role to play in investing in clean energy innovation. The private sector, particularly energy production companies and utilities, typically underinvests in clean energy innovation—in part because energy technologies are more capital intensive and the path to market is more time intensive and complex.[77] Moreover, the private sector cannot properly capture the full benefits of long-term investments in energy innovation. As a result, most private sector energy investments are later stage and near product development, creating investment gaps in clean energy research and development, technology prototyping, first-of-kind demonstration, and early commercialization. Even if the private sector was more willing to invest, fossil fuel technologies are deeply entrenched in the global energy market and have received (and continue to receive) nearly a century's worth of public subsidy and

regulatory support, giving it a distinctive advantage over competition and deterring private investment in clean energy innovation.[78]

According to the IEA, high-income countries invested on average $15 billion (in U.S. dollars) per year in clean energy RD&D since 2009, including nuclear RD&D (fusion and fission), carbon capture, fuel cells, smart grid technologies, electric vehicles, solar PV, wind power, and energy efficiency.[79] RD&D investments reached a peak in 2009 at roughly $20 billion because of additional investment through temporary economic stimulus packages in response to the global recession, but funding fell to $17 billion in 2011. Emerging countries have also started investing in clean energy RD&D—Russia, China, Mexico, and India invested roughly $6 billion in RD&D in 2008, the last year data are available, though China represented 80 percent of investments.[80] Figure 5 illustrates the major high-income and emerging country investors in clean energy RD&D as a share of GDP.

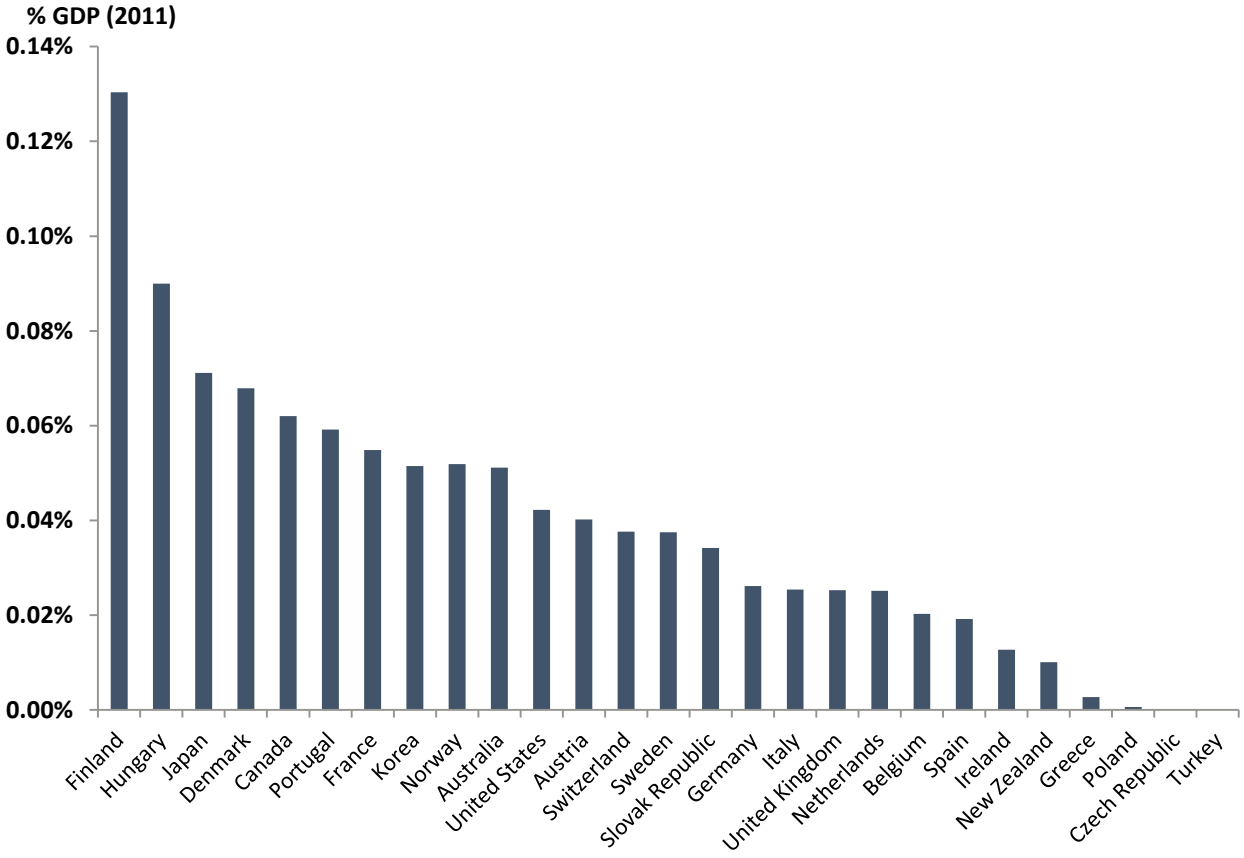

FIGURE 5: 2011 Government investments in clean energy RD&D as a percentage of total 2011 GDP, also called RD&D intensity. Investment data from IEA and GDP data from the World Bank.

In total, public investment in global clean energy RD&D from high-income and emerging economies is approximately $23 billion. Unfortunately, public clean energy RD&D investment is a far cry from what is needed to address climate change. The IEA calculates that the global public investment gap in clean energy RD&D is as great as $70 billion per year. In other words, investment needs to increase by three to four times to solve critical technological challenges and lower costs.[81]

In comparison, global public spending on clean energy deployment subsidies and private sector investment in financing clean energy projects far outpace RD&D. The Pew Charitable Trusts reports that global spending topped $254 billion in 2013, down 11 percent from 2012, but remaining above $250 billion for the fourth straight year.[82]

In high-income countries, the disparity between investments in RD&D and deployment are similar. In the United States, between fiscal years 2009 and 2012, 71 percent of direct federal investments in clean energy went to deployment. During the same period, public investment in deployment nearly tripled, while investment in RD&D projects either remained steady or declined. General Electric's CEO of Energy in Germany, Stephan Reimelt, recently expounded on this imbalance in Germany, one of the major supporters of clean energy policy in the world—stating that "Germany should focus on innovation rather than subsidies and building. There is 230 million euros [$315 million U.S.] of R&D budget for [clean energy] and 20 billion euros [$27 billion U.S.] of subsidies for renewables."[83] Yet climate advocates and policymakers strongly support a much stronger emphasis on deployment. Known as the "deployment consensus," this position leads to a pronounced shift in the national and global policy emphasis toward deploying existing technologies at the detriment of a more cohesive energy innovation approach.[84]

Subsidies can certainly help create early markets for new technologies, particularly when there are entrenched incumbents like fossil fuels. But they are neither sufficient to drive technology costs down enough to be cheaper than fossil fuels, nor replicable in low-income countries that do not have the ability to afford expensive subsidies, nor possible in high-income countries without the political will to support expensive subsidies long term.[85] For example, high-income countries often debate the cost competitiveness of clean energy by comparing the "levelized costs" of different alternatives. Yet, levelized costs matter less in low-income countries where the upfront costs of any energy technology remain a major barrier to adoption.[86]

> "The IEA calculates that the global public investment gap in clean energy RD&D is as great as $70 billion per year."

Many high-income countries are beginning to realize that the deployment consensus may be untenable long term. Germany is viewed as the poster child of clean energy policy because of its generous solar and wind feed-in tariff subsidy, which has produced some positive results—by 2014, wind and solar energy produced 15.9 percent of Germany's electricity.[87] Even so, German brown coal use has increased to its highest levels since 1990 to provide a cheap backup to intermittent wind and solar, and to provide base load power as nuclear plants come offline. By extension, Germany's greenhouse gas emissions continue to rise even with wind and solar.[88] As a result, Germany is rethinking whether it can afford scaling up wind and solar deployment even further with more subsidies; the country cut its solar subsidies by as much as 29 percent in 2012 with further cuts expected in 2014.[89] Similarly, Italy began regularly cutting its solar subsidies in 2011 and Spain started cutting renewable energy subsidies at the beginning of 2012.[90] Greece, France, and the United Kingdom have also cut different clean energy subsidies since 2008 as part of budget austerity or concerns over high-energy prices resulting from subsidy surcharges on consumer energy bills.[91] In short, larger clean energy subsidies are not feasible under economic and political constraints in high-income countries. And for low-income economies looking for cheap energy access, deep-pocketed government subsidies are simply not possible.

International Institutions Emphasize Deployment, Not Clean Energy Innovation

International institutions like the World Bank, United Nations (UN), and other global climate investment funds play a key role in coordinating climate policy and investing in clean energy, mostly for low-income and emerging economies. But their climate and clean energy strategies are often little more than extensions of the "deployment consensus" approach practiced ineffectively by most high-income countries. It is premised on the notion that "every little bit helps," and that policy modestly boosting energy efficiency or supporting a small number of clean energy technology deployments is useful. But as this paper has already argued, modest efficiency gains are a drop in the bucket.

Institutions' clean energy deployment-focused strategies fail in two ways. First, they limit the overall impact of international investments for clean energy and energy access because they do not advance significant innovation to lower clean energy costs and increase performance. Second, emphasizing the deployment of existing clean energy technologies potentially forces more expensive energy choices on low-income countries. The longer the World Bank and other international institutions support the deployment of existing and expensive clean technology over clean energy innovation, the harder it will be to meet long-term poverty reduction, economic development, and climate mitigation goals.

The United Nations Will Not Solve Climate Change and Energy Poverty Without Innovation

The United Nations (UN) is the leading international institution for coordinating climate and energy initiatives, yet after almost 30 years of negotiations, collaboration, and effort, global carbon emissions continue to increase. This is largely a result of the UN putting nearly all its focus on carbon targets and deploying existing technologies rather than on driving down the cost of clean energy through innovation.

The UN is working to address global climate change in a number of ways. It hosts the Intergovernmental Panel on Climate Change that authoritatively synthesizes the peer-reviewed science on global warming to educate policymakers. It's convening the UNFCCC process to replace the failed Kyoto Protocol with a new international climate agreement by 2015, though as discussed previously, this effort largely advances the status quo. And in September 2011, UN Secretary-General Bai Ki-moon launched *Sustainable Energy for All* (SE4ALL), a global initiative to mobilize action from around the world to achieve three objectives by 2030:

- Providing universal access to modern energy services;
- Doubling the global rate of improvement in energy efficiency;
- Doubling the share of renewable energy in the global energy mix.

In particular, SE4ALL provides a unique mechanism for the UN to advance climate policy and energy access by collaborating with other countries and institutions. More than 80 countries, the World Bank, the African Development Bank and the Inter-American Development Bank support it, and several commitments have already been made: Bank of America committed $50 billion over 10 years to finance energy efficiency, renewable energy, and energy access projects; Toyola Energy in Ghana committed to sell at least 3 million energy-efficient cookstoves and 30,000 solar lanterns and small home systems to poor households in Sub-Saharan Africa by 2020; and Philips committed to improving the energy efficiency of its entire product and solutions portfolio by 50 percent (compared to 2009) by 2015.[92]

While these commitments are certainly laudable, SE4ALL is set to have an underwhelming impact on clean energy and energy access because the UN is limiting itself to deployment rather than moving toward a more comprehensive innovation strategy. One must look no farther than the level of energy

access SE4ALL commitment technologies can provide compared to what many would consider "modern energy access." For instance, many leading thinkers argue that modern energy access could mean using solar lanterns and small electricity generating systems, which even when widely distributed, will not offer energy access equitable to that in high-income countries.[93]

As Todd Moss of the Center for Global Development describes, the refrigerator of an average American uses nine times more energy than that consumed by an average Ethiopian citizen.[94] Put another way, IEA defines "modern energy access" as 100 kilowatt hours (kWh) per person per year, or the same amount of electricity consumed by the average American in three days, and the average European in five days.[95] Providing access to any level of energy is important for low-income countries, but limiting the goal to only include small, distributed, low-carbon technologies is a failure on the part of the UN to provide low-income countries a viable path to the level of energy access benefitting high-income countries.

Actually eliminating energy poverty will take more than just private-sector pledges and small low-carbon technologies like solar lanterns. Rather, it will take innovation, cheaper clean energy technologies, technology road-mapping, innovation ecosystem mapping, and considerable deliberation on how to leverage and enhance the innovation capacities of high-income, emerging, and low-income countries to deploy the type of energy technologies needed to put low-income countries on the same energy access level as high-income countries. While the UN has the convening capability to take a more aggressive step toward developing a comprehensive innovation strategy for reaching these goals, it has yet to do so.

"Providing access to any level of energy is important for low-income countries, but limiting the goal to only include small, distributed, low-carbon technologies is a failure on the part of the UN to provide low-income countries a viable path to the level of energy access benefitting high-income countries."

The World Bank Is Making the Same Deployment Mistakes as High-Income Countries

The World Bank provides financial and technical assistance to developing countries, which can have a significant impact on international energy projects. For nearly a decade, the World Bank pursued a piecemeal energy development strategy in low-income and emerging countries by mainly financing electricity transmission and distribution networks to address rural poverty. By 2011, the World Bank's lending strategy was redesigned to prioritize the deployment of existing renewable energy and energy efficiency technologies over the development of fossil fuels, namely coal. This approach is little more than an extension of the "deployment consensus" implemented in high-income countries. Internationally, the deployment consensus potentially forces more expensive clean energy on low-income countries instead of prioritizing affordable technology that alleviates energy poverty or clean energy projects that advance innovation.

The World Bank is directly composed of two lending organizations that have an impact on clean energy development. The International Bank of Reconstruction and Development (IBRD) provides financing to developing and emerging countries to reduce poverty through sustainable development by raising money on international markets or issuing bonds. The International Development Association (IDA) provides loans and grants to the poorest developing countries in the world for infrastructure, human, and economic development. IDA must raise its money from its 172 member countries every three years because, unlike IBRD, it does not earn a return on its investments. But not all member countries provide

funding to IDA—for example, the most recent round of funding procured almost $50 billion from 51 countries to benefit the 82 poorest countries.[96]

> "The World Bank's approach to climate finance is little more than an extension of the "deployment consensus" implemented in high-income countries."

The share of investments going to energy and climate-related projects through the IBRD is about 7 percent to 11 percent, with the majority of investment (an average of about $645 million annually) lent to energy efficiency projects.[97] IDA investments are more evenly distributed, with $789 million going to energy efficiency projects between 2007 and 2013, compared to $208 million between 2003 and 2006, and $837 million in renewable energy generation projects during the same period, up from $123 million between 2003 and 2006. In fact, between 2011 and 2012, IBRD and IDA approved 32 projects constituting nearly $3.4 billion in grants or loans toward renewable energy and energy efficiency projects.[98] The largest of these is the 10-year project developing the 500 megawatt (MW) Ouarzazate solar power plant in Morocco; the total project cost is estimated at $1.4 billion, but total World Bank financing for the project is only $200 million.[99]

As shown in Tables 1 and 2, IBRD and IDA projects support a mix of technologies, including wind, solar, geothermal, hydropower, lighting, oil and gas, and grid build-out for rural energy expansion.[100] Both the IBRD and the IDA have prioritized expanding transmission and distribution systems during the last few years. The majority of IBRD's support for transmission and distribution is for projects in Central and East Asia and Europe, while IDA's transmission support is approved for projects in least-developed countries in Africa and East Asia. For example, IDA approved a $684 million contribution toward the Eastern Electricity Highway Project—the first phase of the larger Eastern African Power Integration Program, which is expected to provide 212 million people with electricity access.[101]

Project	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Energy Efficiency	$0	$21	$172	$15	$12.5	$17.5	$10	$97.7	$0	$552	$100	**$998**
Renewable Energy	$32	$0	$87	$3.5	$40	$0	$407	$25	$172	$155	$38.3	**$998**
Large Hydropower	$0	$0	$0	$0	$120	$597	$37.8	$8	$283	$793	$367	**$2206**
Oil, Gas and Coal	$0	$50	$423	$5	$0	$135	$400	$70	$0	$305	$60	**$1448**
Other Energy	$37.2	$29.9	$0	$20.5	$205	$4	$100	$5	$0	$100	$154	**$656**
Thermal Generation	$0	$0	$80	$7.2	$449	$350	$4	$15.4	$82	$188	$230	**$1406**
Transmission/ Distribution	$289	$464	$288	$304	$552	$740	$1025	$996	$413	$1596	$251	**$6918**
Total	**$2361**	**$2569**	**$3055**	**$2361**	**$3386**	**$3852**	**$3993**	**$3227**	**$2961**	**$5701**	**$3213**	**$14630**

TABLE 1: Total energy IDA credits and grants by type of project (millions US$).[102]

While a share of IBRD and most IDA loans aim toward projects designed specifically to advance energy access and not necessarily mitigate climate change, a significant portion of IBRD's investments in renewable energy after 2008 was used to fund "policy loans," which support governments implementing clean energy and climate policies, specifically for countries that have committed to reducing carbon emissions under the Kyoto Protocol. For example, IBRD approved policy loans for Mexico and Poland in 2009 and 2011 to assess the economic impacts of carbon regulatory policies and subsidize the adoption of energy efficient and renewable energy technologies. These loans emphasize support for carbon caps and deployment subsidies for existing technology, rather than clean energy innovation, as the solution for widespread adoption of clean energy in low-middle income and emerging economies.

Project	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Energy Efficiency	$39.2	$0	$35	$739	$133	$650	$360	$1306	$1664	$0	$397.8	**$5324**
Renewable Energy	$10	$202	$87	$86.3	$0	$170	$2043	$70	$875	$0	$120	**$3663**
Large Hydropower	$0	$0	$0	$106	$0	$400	$0	$0	$1639	$500	$0	**$2645**
Oil, Gas and Coal	$30	$0	$18	$0	$0	$0	$0	$0	$0	$100	$0	**$148**
Other Energy	$12.1	$0	$0	$0	$100	$401	$0	$0	$0	$750	$0	**$1263**
Thermal Generation	$0	$0	$0	$336	$45	$0	$680	$600	$0	$293	$585	**$2539**
Transmission/ Distribution	$141	$0	$100	$225	$469.4	$1378	$2735	$5273	$398	$180	$365.5	**$11265**
Total	**$2235**	**$2206**	**$2245**	**$3498**	**$2754**	**$5007**	**$7827**	**$9259**	**$6587**	**$3835**	**$3481**	**$26847**

TABLE 2: Total energy IBRD loans by type of project (millions US$).[103]

The World Bank's recently released 10-year Energy Sector Strategy includes a financing focus on expanding energy access, increasing lending for renewable energy projects, prioritizing energy efficiency, constructing new hydropower where appropriate, and increasing carbon emission analysis.[104] But like IBRD's policy loans and the World Bank's clean energy investments writ large, the new provisions unsurprisingly fail to incorporate the importance of supporting projects that drive down clean energy costs and spur innovation, such as the demonstration and smart deployment of emerging technologies. Instead, the provisions largely perpetuate the Bank's standard clean energy deployment consensus lending strategy.

International Climate Funds Make the Same Deployment Mistakes as the World Bank

The UN and other multilateral development banks have created additional climate investment funds—such as the Global Environment Facility (GEF), the Clean Technology Fund (CTF), and the yet-to-be-funded Green Climate Fund—to accomplish climate and clean energy policy goals. Each of these financing mechanisms make the same mistakes as the World Bank and strongly emphasize funding clean energy deployment projects for existing technology.

For example, the GEF was founded in 1991 as a financial mechanism to support a number of UN conventions, including the UNFCCC, the Convention on Biological Diversity, the Convention to Combat Desertification, and the Stockholm Convention on Persistent Organic Pollutants.[105] It's now the largest international public funder of environment-specific initiatives, providing $12.5 billion in grants and leveraging $58 billion in co-financing since 1991.[106] Unlike the IBRD arm of the World Bank, the GEF provides grants instead of loans, specifically for environmental projects related to climate mitigation, adaptation, biodiversity, and land degradation. Its wide-ranging responsibilities are combined with an obligation to facilitate coordination between the GEF's member countries and other international institutions, banks, NGOs, and the private sector to cover the "incremental" costs of transforming a development-oriented project into one with environmental benefits.[107]

While the GEF serves an important role as a grant-giver rather than a lender like other development banks, the success of GEF projects is measured mainly by their ability to avoid or immediately reduce carbon emissions in developing and emerging countries. With such a limited metric for success, the GEF fundamentally focuses on clean energy deployment projects, rather than a broader innovation-based portfolio with an eye toward how best to facilitate deep carbon reductions in the future.

A similar example is the Clean Technology Fund (CTF), which was established in 2008 to address financial gaps in meeting the Millennium Development Goals by 2015. In comparison to GEF, CTF was conceived with innovation in mind and provides "positive incentives for accelerating and scaling-up the

deployment, diffusion, and transfer of low carbon technologies" through technology programs supporting energy efficiency and renewable energy—concentrating on solar power, combined cycle gasification power plants, large-scale wind, residential lighting, and transportation technologies.[108] Some projects, like CTF's $150 million investment plan for clean energy development in Morocco or its support for India's Jawaharial Nehru National Solar Mission ($775 million), include or even prioritize more RD&D of emerging solar and wind technology.[109]

> "CTF's intention to improve clean energy technologies is correct, but it falls short because projects are evaluated in essentially the same way as GEF projects—through a combination of metrics assessing avoided GHG emissions, installed renewable capacity, number of passengers using low-carbon transportation, and annual energy savings."

But the majority of CTF funding is focused on a mix of technology deployment projects, policy planning, and urban infrastructure improvements rather than innovation. CTF's intention to improve clean energy technologies is correct, but it falls short because projects are evaluated in essentially the same way as GEF projects—through a combination of metrics assessing avoided GHG emissions, installed renewable capacity, number of passengers using low-carbon transportation, and annual energy savings.[110] As long as project "success" can be satisfied by deploying existing—and expensive—renewable energy, rather than by metrics that measure projects' innovation capacity and potential, CTF will continue to fail to drive supply and demand for cheaper and better technologies.

A final example of this type of financing mechanism is the Green Climate Fund, which was established in 2010 to "play a key role in channeling new, additional, adequate and predictable financial resources to developing countries and…catalyze climate finance, both public and private, and at the international and national levels."[111] While the UN has not designated a formal goal for the Fund, the 2009 climate talks in Copenhagen suggested the necessity of raising $100 billion for climate financing by 2020, and at least $30 billion in the short term. Unfortunately little of that money has materialized—as of February 2013 the Fund had only accumulated $33.8 million from Germany and South Korea.[112] Conflict continues between low-income and high-income countries over the involvement of the private sector and the process for project selection and financing, which has yet to be finalized. While supporters of the Fund insist its necessity as a "catalyst" of public investments in low-carbon infrastructure—particularly in emerging countries—the dearth of contributions indicates less willingness from high-income countries to participate in another fund to support clean energy deployment.[113]

By continually prioritizing deployment-centric financing strategies, these international funding mechanisms fail to accelerate clean energy innovation. For climate mitigation, they're no different from the limited subsidies provided by high-income countries to induce modest gains in clean energy. Unfortunately, that's not nearly enough to address climate change, nor is it enough to advance energy access.

International Green Mercantilist Policies Are Limiting Clean Energy Innovation

"Green mercantilism" refers to the use of discriminatory economic policies that give domestic clean energy firms an unfair advantage in national and global markets. A major departure from rules-based trade, mercantilist behavior is represented by "beggar-thy-neighbor" policies, including lax intellectual

property (IP) enforcement, forced technology transfer, export subsidies, discriminatory technology standards, barriers to imports, and preferential treatment of domestic firms.[114] Nations grow their own protected clean energy industries in the short term, but stifle global clean energy innovation in the long term—directly impacting whether the world can mitigate climate change.

Green mercantilism is perpetuated in the global climate policy ecosystem in two ways. First, many emerging countries, like China and India, are implementing mercantilist policies (e.g., below-market subsidies and barriers to imports) to quickly gain a competitive advantage in the clean energy economy and build domestic industries. Second, international institutions like the World Bank often "look the other way" when financing energy projects in countries that utilize green mercantilist policies, providing an implicit nod of approval to countries leveraging mercantilist policies.

> "Green mercantilism" refers to the use of discriminatory economic policies that give domestic clean energy firms an unfair advantage in national and global markets, and is a major departure from rules-based trade."

In both cases, policymakers and climate advocates fail to see past green mercantilism's short-term benefits for its significant long-term costs. Green mercantilism certainly has boosted the global clean energy market—Chinese manufactured solar panels, for example, will continue to increase solar deployment around the world as long as China continues to heavily subsidize them. But this has also led to a sharp reduction in market share and rates of profit of solar companies in developed nations. This matters to innovation because it is these companies that are much more likely to invest in RD&D and patent new breakthroughs; they are less able to do so if their intellectual property is stolen or if their market share and profits decline due to unfair competition.[115] While artificially lowering the price of clean energy through mercantilist subsidies may temporarily boost low-carbon technologies, it is detrimental to the clean energy innovation needed to mitigate climate change.

Emerging Mercantilist Countries Are Stifling Clean Energy Innovation

Green mercantilist policies often help countries gain global market share in clean energy industries. While least-developed countries use protectionist policies to build modest economic development to reduce poverty for their people, emerging countries are implementing aggressive green mercantilist policies to overtake entire markets.

For example, China has put in place a host of mercantilist policies in an effort to gain global clean energy market share. China's National Development and Reform Commission (NDRC) requires 70 percent domestic content for all wind turbines produced in China.[116] The 2007 Foreign Investment Industry Guidance Catalogue listed wind turbine manufacturing as an encouraged industry for foreign participation, but foreign firms that manufacture wind turbines capable of producing more than 1.5 MW of power were required to engage in domestic joint ventures or partnerships. China's renewable energy policy explicitly encourages transfer of wind turbine technology from the foreign to the domestic enterprise.[117] And while policymakers in high-income countries often bemoan government policies that "pick winners and losers," China is redefining the term: it's chosen 134 out of 500 domestic solar companies to receive government support, allowing the rest to fail.[118]

China also employs forced technology transfer practices, which require foreign firms to transfer intellectual property to technology as a condition of market access.[119] In accordance with its New Energy Vehicles plan, China requires foreign electric vehicle makers to transfer IP to a Chinese automaker as a requirement for gaining access to the market.[120] A recent case involved General Motors (GM) trying to gain access to China's 50 percent tax credit for electric vehicles, which domestic firms already have access to. GM could not access the tax credit for its Chevy Volt without permission, and while in negotiation, the Chinese government began placing "heavy pressure on the company to transfer one of the Volt's three core technologies to a joint venture with a Chinese automaker."[121] GM eventually balked, but other firms—Nissan in particular—have come out against participating in such deals.[122] Although China is not the only country to practice forced technology transfer, it is considered the most frequent offender.[123]

Another mechanism for green mercantilists is the introduction of local content requirements, which mandate that a certain percentage of goods or services sold in a country must be produced with local content.[124] India has introduced local content requirements for wind turbines and solar PV. The government is requiring 50 percent local content for wind projects over 10 MW that began operation after January 2012, and for solar projects between 10 KW and 10 MW, India requires 60 percent local content.[125] India has further introduced local content requirements for grid-connected solar PV and solar thermal projects. In February 2013, the United States requested World Trade Organization (WTO) dispute settlement consultations with the Indian government concerning the domestic content requirements in India's national solar program.[126]

Without a doubt, mercantilist-backed clean energy imports have had a significant impact. From 2010-2011, cheaper Chinese solar panels contributed to a 69 percent increase in global solar installations.[127] Even with U.S. tariffs, Chinese-manufactured solar panels represent over 35 percent of U.S. solar installations of first-generation crystalline solar panels.[128] In fact, Chinese solar imports are potentially much higher as China has taken advantage of a loophole in the U.S. solar tariff to import its panels using regionally produced solar cells, such as those from Taiwan.[129] No one can deny that cheap Chinese-made solar panels are the cornerstone of deployment around the world today.

> "The Indian government requires 50 percent local content for wind projects over 10 megawatts (MW) that began operating after January 2012, and 60 percent local content for solar projects between 10 KW and 10 MW."

While it is understandable that the countries engaged in green mercantilism will defend their policies on domestic economic grounds, it is more surprising that many climate advocates defend them as well, arguing that green mercantilist policies help lower prices, thus enabling other countries to deploy more clean energy. Former New York City Mayor and staunch climate advocate Michael Bloomberg summarizes these views best when he argued that if "…the Chinese want to support our economy, send it in."[130] Indeed, many feel that if mercantilist countries are willing to subsidize their products in order to make them cheaper for foreign consumers, non-mercantilist countries should take advantage of lower energy prices. Likewise, some industries that depend on foreign imports (e.g., solar panel installers) agree, arguing that subsidized products lead to expanded demand for their services and create jobs. From their perspective, ending green mercantilist policies simply increases prices and reduces clean energy deployment.

> "If the goal is more deployment of existing clean energy technologies, then green mercantilism is a positive development. But if the goal is the development of next generation clean energy technologies, green mercantilism is a hindrance in that it adversely affects global innovation capacity, reducing the incentive of firms to invest in more innovative technologies."

If the goal is more deployment of existing clean energy technologies, then green mercantilism is a positive development. But if the goal is the development of next generation clean energy technologies, green mercantilism is a hindrance in that it adversely affects global innovation capacity, reducing the incentive of firms to invest in more innovative technologies. For example, mercantilist-backed Chinese clean energy firms are simply not as innovative as many firms in more developed areas like Europe, Japan and the United States, as they invest a lower percentage of revenue in RD&D and focus patenting on lower-value innovations.[131] China patents 61 percent less than Japan and 72 percent less than the United States in clean energy, and more of its patents are in more mature fossil fuel technology.[132] Green mercantilism hurts, rather than helps, the world make the transition to clean energy. While making clean energy artificially cheaper boosts production and deployment in the short term, it harms clean energy innovation in the long term, limiting the world's chances of addressing global climate change.

International Institutions and Climate Advocates Turn a Blind Eye to Green Mercantilism

While international institutions do not explicitly practice or facilitate green mercantilism, they certainly allow it to continue unabated by financing projects in mercantilist countries. More so, green mercantilism is perpetuated by a growing chorus of international climate advocates who argue that compulsory licensing—the transfer of clean energy IP from high-income countries to low-income countries for little to no cost—is a chief method for scaling up global clean energy deployment. In both cases, the international climate debate threatens to slow down global clean energy innovation and potentially lock in more expensive technologies, which adversely impacts mitigating climate change as well as advancing energy access.

In the international climate policy debate, there is significant controversy concerning whether high-income countries should transfer technologies to low-income countries so they can rapidly deploy clean energy. India's climate negotiators have argued that "many of the technologies that can help it and other developing countries achieve a lower carbon growth are out of their reach due to [intellectual property rights] and prohibitive costs."[133] A joint position paper in 2007 from Brazil, China, India, Mexico, and South Africa listed an "agreement on transfer of technologies at affordable costs for accelerated mitigation efforts in developing countries" as a critical policy issue to address.[134] Bolivian President Evo Morales advocates for providing low-income countries with clean energy technologies "so that all countries can access products already patented…free of cost."[135] UN Development Program Climate Change Advisor Preeti Soni argues that there is a critical need for international agreement so that high-income countries can transfer clean energy IP to low-income countries to help them "'leap frog' to highly efficient technologies rather than travel along a slow 'market driven' curve towards the desired technology," which could be accomplished through mandatory licensing of IP or regulation on licensing fees.[136]

Many international institutions and climate advocates believe compulsory licensing for clean energy should follow the same principles as medicine. Under the Doha Declaration of the Agreement on Trade

Related Aspects of Intellectual Property Rights (TRIPS), developing countries are allowed to use compulsory licensing to manufacture generic drugs under situations of extreme urgency or national emergency, removing the barrier of higher drug prices to advance human health. But many emerging countries intend to use the TRIPS Declaration for more than just medicine. For example, India "has made clear that it views compulsory licensing as an important tool of industrial policy for green technologies…"[137] It has gone so far as to advocate for it being established as a key principle under international climate negotiations, set to conclude in 2015.

But clean energy is not medicine, and the principles of the TRIPS Declaration on compulsory licensing do not necessarily hold. The benefits of medicine accrue to individuals and provide an immediate solution to human health, particularly in countries incurring medical emergencies. A similar comparison can be made to energy technologies as they pertain to energy poverty in low-income countries, because energy access is a fundamental solution to advancing economic development and alleviating poverty. But the benefits of clean energy, as they pertain to climate change, accrue to the planet as a whole through lower carbon emissions. Countries that implement compulsory licensing in the name of climate change might lower their carbon emissions, but at the expense of greater rates of global innovation, which hurts other countries' (and the world's) efforts to reduce carbon emissions. Mitigating climate change requires globally impactful solutions, not just actions by individual countries. Compulsory licensing of clean technology is just another flavor of deployment subsidies, lowering the price of high-cost clean technologies in the hope that they will be widely adopted.

Of course, emerging countries and advocates of compulsory licensing are correct to worry about how the world is going to rapidly deploy clean energy to all countries to mitigate climate change. But like green mercantilism generally, compulsory licensing slows the rate of global clean energy innovation by removing a major incentive for innovators to innovate. Foreign clean technology firms will invest less in innovation if compulsory licensing reduces the returns on innovation. This is even more pronounced when compulsory licensing is not just used to transfer clean energy to a specific domestic market, but when it is used to build globally competitive domestic firms. For example, India's recent Intellectual Property Appellate Board suggested that an international patent could be subject to a compulsory license if it is not manufactured in India.[138] In other words, India may hold compulsory licensing as a bargaining tool to force international clean energy firms to manufacture their products within its borders. Similar situations have occurred in the pharmaceutical industry, where emerging countries have not just used compulsory licensing to provide cheap medicine to their people, but also to build domestic 'copycat' industries that sell internationally. This again lowers sales for more innovative clean technology firms, compromising their ability to reinvest in next-generation innovations.

Even though compulsory licensing stifles global clean energy innovation, many international institutions turn a blind eye to the practice. The UN continues to entertain international climate negotiations that include the potential for compulsory licensing, even though the UN's IPCC recently found that "despite short-run technology transfer benefits, compulsory licensing of mitigation technologies may not be desirable in the long-run."[139] And international development banks continue to provide significant support to emerging countries that utilize green mercantilism and compulsory licensing. Between 2008 and 2014, the World Bank IBRD program has provided $1.3 billion and $3.25 billion in financing to China and India respectively to build energy efficiency, renewable generation, transmission, and hydropower projects.[140] While not directly endorsing green mercantilist practices, the World Bank and other international funding mechanisms are providing tacit approval of mercantilist clean energy and climate policies by allowing these practices to continue unabated.

PRINCIPLES FOR AN INNOVATION-BASED GLOBAL CLIMATE POLICY

After more than a decade of global climate policy efforts with no net carbon emission reductions to show for it, it's time to acknowledge that we need new approaches and policies to bend the global carbon curve down to near zero. For nearly three decades, climate advocates and policymakers have sought certainty in addressing climate change. Carbon caps are favored because they purportedly provide certainty by mapping out measurable future carbon reductions. Subsidies provide immediate certainty that clean energy is advancing today, rather than occurring in some hopeful future. And carbon pricing provides a simple policy mechanism that many argue will re-orient economies toward addressing climate change while avoiding governments "picking winners"—providing advocates with a useful bumper-sticker policy to build bipartisan support.

The reasons why these approaches have failed are numerous and pervasive. The climate policy community has mistakenly equated reducing the *price* of clean energy with reducing its *cost* for too long. Previous efforts to shape clean energy policy have largely focused on reducing the relative price, either through subsidizing clean energy or by increasing the price of fossil fuels. If that can just happen, some believe, fossil fuels will be consigned to the dust bin of history. The climate policy community has also treated climate change as a more narrow pollution problem to be solved through setting targets and limiting consumption, when what we're actually facing is a monumental technological challenge to jump-start a global energy transition and complete it in record time compared to energy transformations of the past.

The foremost goal of climate policy should be to reduce the cost of clean energy through technological advancement. Only then will all countries deploy clean energy—not out of environmental obligation, but because it makes economic sense. Mitigating climate change requires an estimated 93 percent reduction in the carbon intensity of the global economy, which necessitates a complete shift in energy consumption.[141] Mandating or encouraging the broad-scale deployment of existing technologies—whether in high-income or low-income countries—has been and will continue to be impossible due to the high costs of those technologies and political resistance to paying those costs.

> "The question of international climate policy should not be: 'how should the world implement carbon reduction targets or subsidize clean energy?' It should be: 'how can the world develop affordable clean energy technologies so that natural market forces will drive their ubiquitous adoption?'"

The question of international climate policy should not be: "how should the world implement carbon reduction targets or subsidize clean energy?" It should be: "how can the world develop affordable clean energy technologies so that natural market forces will drive their ubiquitous adoption?" Given that the dominant neoclassical economic thinking around the world considers innovation to be a black box, the lack of an explicit answer to this question is unsurprising.[142] As a result, the global climate community has spent much of its time and efforts putting the cart before the horse—jumping immediately to implementing a clean energy economy without assessing whether it has all of the necessary tools and technologies.

The international climate community needs to begin viewing policy solutions through the lens of innovation so that decades of work offer more than little progress. Recognition of the following realities is necessary to move beyond current policies:

- The paramount goal of climate policy should be to make the unsubsidized cost of clean energy cheaper than fossil fuels so that all countries deploy clean energy because it makes economic sense.

- Innovation of cheaper technologies, and not just deployment of existing technologies, will be the principal way to achieve clean energy affordability.

The following represents a new framework for innovation-based global climate solutions—a set of basic principles that inform how to shape an effective global energy innovation ecosystem to mitigate climate change by making clean energy cheaper than fossil fuels.

Countries Have Differentiated Policy Responsibilities for Addressing Climate Change

A natural schism exists between high- and low-income countries because high-income countries have historically emitted most carbon emissions to date, but low-income countries are most susceptible to the damaging effects of climate change. During the last UNFCCC negotiation in Warsaw in 2013, representatives from 133 developing countries staged a walkout over the refusal of high-income countries to consider paying for the damages of climate change.[143] It is clear that not every country must "pay" or engage equally toward mitigating climate change. Actionable and effective international climate policies must be flexible enough to allow all countries to participate in ways that suit their national interests, competitive advantages, and innovation ecosystems—not just broad demands to meet climate targets.

Robust Government Support for Innovation is Central to Making Clean Energy Cheap

Clean energy innovation is not "manna from heaven." The market does not magically produce new products and services out of thin air. Nor do innovations truly come from garage tinkerers. Government policy plays a key role in driving it. This is particularly true with clean energy because energy is a fungible good, has long development cycles, and has high up-front deployment costs. But high-income countries that are well-positioned to drive innovation are still often hesitant to invest in it; uncertain rates of return and potential for spillover make it difficult to domestically capture the majority of the benefits of RD&D investments. Nonetheless, without more robust public investments in clean energy RD&D, it is unlikely that the world will develop the needed technologies to reduce carbon emissions soon enough.

Climate Policy Should Provide New Technologies a Niche Market

Fossil fuels have received over a century of government subsidies, government-protected markets, significant infrastructure development, and ongoing political support. New energy technologies have little opportunity to gain a foothold in the market to compete, regardless of their long-term cost and performance potentials. The result is that investments in innovation are generally suppressed in the private energy market, far below levels seen in more innovative industries. Climate policy should provide early, temporary, innovation-driven deployment support to help emerging clean energy technologies reach commercialization so that they have a fair chance of competing.

Climate Policy Should Expand Clean Energy's Market Size

Like innovation-based industries, clean energy has low marginal costs of production and high costs of research, design, and development. As a result, larger market size increases private sector revenues,

which can in turn be reinvested into RD&D to generate next-generation innovations. Climate policy should actively remove barriers to investment in clean energy or barriers to expanding clean energy into new international markets to help private industry reinvest into the future.

Countries and Institutions Should Limit Unfair Clean Energy Market Competition

While large markets enable firms to produce and sell more products and thus reinvest in next-generation clean energy technologies, unfair competition can reduce firms' abilities to invest in innovation. In particular, government policies to prop up competitors that otherwise would go out of business create excess competition, which limits the potential profits that innovators can generate by taking risks and entering the market. For example, state-backed enterprises and discriminatory government procurement prop up less-competitive firms, limiting the market potential for more innovative technologies.

Countries and Institutions Should Support Strong Clean Tech IP Protection

Strong IP is fundamentally important to enabling clean energy innovators to capture more of the benefits of their own risk taking and investments. Without it, innovators do not realize the full economic gains from their inventions, limiting their ability to reinvest back into innovation or enter the market at all. If competitors are able to enter the clean energy market because they obtained IP at below-market price—such as through IP theft, compulsory licensing, or by capturing sales the innovator normally would—it reduces the overall incentive to innovate. Clean energy policies should support strong IP protections to facilitate long-term sustainable innovation.

Climate Policy Should Not Force Countries to Pay More for Clean Energy

Access to modern energy systems has a strong positive impact on human well-being and economic growth. The fact that more than a billion people do not have access to energy is limiting progress on a host of issues, including eradicating extreme hunger and poverty, improving maternal and child health, and achieving universal primary education.[144] Improving energy access and mitigating climate change are goals at odds with each other as long as clean energy remains more expensive than fossil fuels. However, forgoing support for cheaper fossil fuel projects prolongs energy poverty or results in low-access countries paying more for clean energy. This imparts unfair additional costs on low-income countries and at best will not solve climate change as the carbon reductions will be too marginal to make any real global difference.[145] The only way to align these two goals is to develop clean energy that is cheaper than fossil fuels.

POLICY PROPOSALS FOR ADVANCING GLOBAL CLEAN ENERGY INNOVATION

Assessing the current state of global climate policy through the principles outlined in this report gives a sense of the weaknesses we face and the challenges ahead. The world underinvests in clean energy innovation, and its current institutions, government investment programs, financing mechanisms, trade policies, and deployment incentives are not linked to any cohesive innovation strategy.

The world will likely not suddenly stop negotiating carbon targets or implementing pricing and subsidy programs, but a strong clean energy innovation approach is needed to reform existing policies to orient international climate policy toward spurring innovation. The following proposals represent crucial methods for instituting an innovation approach to addressing climate change.

Significantly Increase Public Support for Clean Energy RD&D

The core of any clean energy innovation strategy is robust funding for RD&D, which the IEA estimates the world underfunds by roughly $70 billion a year. Given the immediate need to accelerate clean energy innovation, countries with strong innovation capabilities need to take the lead.

International Climate Negotiations Should Include Clean Energy RD&D Targets

To fill the RD&D investment gap, the next round of international climate negotiations should offer the option to meet increasing government clean energy RD&D intensity targets in lieu of, or as a complement to, meeting carbon emission targets. These investment targets should be technology-neutral so as not to discourage investment in technologies such as carbon capture and storage, nuclear energy, energy efficiency, and smart grid technologies. In a 2011 analysis, the Information Technology and Innovation Foundation proposed that RD&D intensity goals between 0.027 percent and 0.065 percent of GDP could be adequate starting points for high-income countries, as long as these goals were scaled up over time.[146]

Such an option offers a high-impact alternative to carbon targets. For instance, it gives countries that for political reasons may not be able to sign on to targets, like the United States, Canada, and China, another option for engaging in international climate policy. For countries fearful that carbon targets would put them at an economic disadvantage, RD&D targets provide an alternative to spur innovation, offering the potential for economic growth, not economic loss. Increasing investment in innovation boosts competitiveness and helps countries "assimilate scientific advances and technology innovations."[147] In other words, countries should be given an innovation-based alternative to global carbon targets, which may allow more countries to sign on to an international treaty and engage in addressing climate change.

High-Income and Emerging Countries Should Strategically Increase Clean Energy RD&D

High-income countries and many emerging economies are better equipped to increase RD&D investment compared to many low-income countries, because of stronger science, research infrastructure, and funding capacity. This is not to say that low-income countries should do nothing in this area; they certainly should as part of a broader domestic economic growth strategy. But for the purposes of addressing global climate change, most high-income and emerging countries are ready today to have a significant impact. Ninety percent of annual RD&D investment comes from high-income countries and emerging economies like Russia and China, and 80 percent of all RD&D occurs in the G8 countries.[148] Because high-income countries are host to more universities and national labs, they train more researchers per capita. In 2010, Finland, Denmark, Korea, Norway, and Switzerland each reported more than 5,000 researchers per million people in residence, while Ethiopia, Burkina Faso, and other low-income countries reported much lower numbers, in the range of 300 to 700 researchers per million people.[149] In addition, many high-income countries have dedicated decades of knowledge building and infrastructure investment to energy research—the U.S. Department of Energy's National Laboratories have been in existence since the late 1930s, for example.[150]

> "Global subsidies for oil, gas, and coal would have to be scaled by just 13 percent to support a $70 billion increase in clean energy RD&D."

The European Union (EU) is a strong regional example of a coordinated attempt to implement a better energy innovation strategy, even if it continues to implement carbon targets and prices. For years, the EU has focused its climate priorities on cap and trade to little effect, but now it is taking energy innovation more seriously. The European Commission's Horizon 2020 research and innovation program provides

$8.2 billion (in current U.S. dollars) for public investment in clean energy RD&D over a 7-year period.[151] While the investment is a relatively small drop in the bucket (the United States will invest over three times as much at current investment levels) and much more public investment is needed, it represents a 25 percent increase in EU investment in innovation.[152]

If countries are not able to unilaterally increase government budgets due to austerity concerns, there are several revenue-raising options that also address other issues with global climate policy. For instance, countries should scale back or eliminate climate-harmful fossil fuel subsidies, and use part or all of the savings to fund clean energy RD&D. Global subsidies for oil, gas, and coal would have to be scaled by just 13 percent to support a $70 billion increase in clean energy RD&D.[153] For example, if the United States eliminated fossil fuel subsidies it could increase clean energy RD&D investment by $4.2 billion.[154]

Countries could also implement a modest carbon tax, which may be more acceptable politically than a cap and trade program or regulatory mandates, and use the revenue to fund clean energy innovation programs. For example, British Columbia is using revenue from its carbon tax to fund the Climate Change and Emissions Management Corporation (CCEMC) to invest in promising clean energy technologies and breakthrough innovations.[155]

For countries with robust fossil fuel resources, fees and taxes on fossil fuel exploration and drilling could also be used to fund innovation.[156] For example, the United States could fully fund its breakthrough clean energy innovation program ARPA-E at $1 billion per year by increasing onshore drilling royalty rates by 4.5 percentage points.[157]

Reform Subsidies to Support Smart Deployment of Clean Energy Technologies

Most high-income countries prioritize supporting deployment of existing clean energy technologies through expensive and often unsustainable subsidies. Many of today's clean energy deployment incentives act as "blunt tools" rather than "smart" innovation policy instruments that support the development of next-generation technologies.[158] Blunt deployment subsidies often work best when technologies are in very early stages of development, but as they mature, the subsidies support declining rates of innovation as companies focus more on incremental improvements to existing subsidized technologies and less on developing new technologies.[159]

The current approach of international institutions to rapidly deploy existing clean energy technologies may modestly expand clean energy adoption, but it does little to slow the global growth of carbon emissions. Moving forward, a number of reforms are needed to accelerate the impact of international institutions within the global energy innovation ecosystem. Smarter deployment policies for countries and international institutions are needed to make subsidies contingent upon continued cost reductions and performance increases, otherwise countries risk simply subsidizing the status quo and failing to address climate change.

High-Income Country Subsidies Should Encourage Innovation

High-income countries should reform existing subsidies into "smart deployment" policies that provide subsidies contingent on continued cost and technology improvement. For example, countries could leverage better tax incentives for clean energy that temporarily support technologies through demonstration and early commercialization, but that sunset once it scales in the marketplace.[160] Countries could also implement performance-based subsidies or incentives that steadily increase over time, requiring technologies to consistently improve to gain government support.[161] And all countries

could leverage their government procurement budgets to act as early adopters of new clean energy technologies, such as for vehicle fleets, micro grids, and renewable power generation for government buildings.[162]

The World Bank Should Finance Smart Deployment in Low-Income Countries

While development banks and other climate finance mechanisms focus in a limited way on deploying existing technologies, many of the programs and funds could consider more large-scale demonstration projects and deployment of next-generation technologies to promote further technology improvements and learning.

The World Bank should prioritize innovation in its energy investment portfolio by supporting the demonstration and deployment of emerging, rather than just existing, technologies to drive innovation. The Bank should execute such an institutional change by using IBRD policy loans to support the implementation of clean energy innovation policy strategies in lower-middle income and emerging countries, moving beyond carbon prices, targets, and subsidies.

The Clean Technology Fund Should Be Redesigned To Focus on Testing and Demonstration

The Clean Technology Fund (CTF) was originally conceived as a mechanism for funding technology-neutral investments in the development and demonstration of transformative technologies.[163] In reality, the CTF ended up looking essentially the same as other clean energy finance mechanisms; it is evaluated by the same metrics—GHG emissions avoided in the short run and additional renewable energy capacity installed—rather than technology performance and achievement of cost milestones. The Clean Technology Fund should be redesigned to represent the premier "clean energy innovation" financial mechanism for low-income and emerging countries to coordinate the testing and demonstration of advanced clean energy technologies.

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Adopting a different metric of evaluation—one that considers technology advancement through demonstration and smart deployment—could leverage additional country pledges and follow-on financing for the fund because of its unique focus on technology rather than GHG abatement.[164] An innovation financing mechanism of this kind could power innovation in clean energy for climate mitigation and energy access, while improving energy access in low-income countries. As the UN and World Bank continue to pursue efforts to get countries to pledge funding for the new Green Climate Fund, these institutions should consider the benefits of an innovation-based climate financing approach for poverty alleviation and climate goals.

The UN Should Encourage Smart Deployment through Leapfrogging for Energy Access

The UN should also be actively involved in identifying opportunities where new, disruptive energy technologies that may not be widely commercially available may find different applications if deployed in energy-poor countries—a phenomenon known as "technology leapfrogging."[165] Technology leapfrogging is defined as the process of "implementing a new and up-to-date technology in an application area in which at least the previous version of that technology has not been deployed."[166] Many development

organizations believe such leapfrogging is possible in low-income countries where large rural populations make building out centralized fossil fuel generation too costly and distributed solar PV the cheapest option.[167] Of course, not every potential energy project would fit this circumstance, but through the lens of affordability and innovation, these projects should become a priority.

For the past few years the UN and other development organizations have supported "technology leapfrogging" for small devices like solar lamps and clean cookstoves. These technologies, while largely unnecessary in high-income countries, address important and specific needs in low-energy-access countries, but still don't provide high-energy access. The UN should expand this leapfrogging approach with a more ambitious program for deploying larger clean energy systems in situations and regions where clean energy is cheaper than fossil fuels. For example, in rural low-income countries that don't have an electricity distribution and transmission system, next-generation distributed clean energy could be more affordable without subsidies than building a centralized coal plant. Rather than building out fossil fuels plus transmission, the UN could support large-scale leapfrogging to next-generation clean energy to expand its market and spur innovation.

The IEA Should Develop Energy Innovation Mapping to Facilitate Smart Deployment

A significant challenge in many low-income countries is a lack of informed strategic energy planning. Lack of data on regulatory structures, market trends, infrastructure, government investments, and institutional involvement often inhibits or undermines the implementation of projects or policy.[168] To correct this, IEA should develop an energy innovation ecosystem mapping initiative for low-income and emerging economies to inform better international clean energy innovation for developing technology test-beds and facilitating smart deployment. The Agency is well positioned to coordinate ecosystem mapping because of its experience in data collection and analysis at the international level. Such an effort should consider in detail relevant national and international energy innovation institutions as well as the ways that knowledge and financing are exchanged.[169] Mapping innovation ecosystems is necessary to inform opportunities for natural synergy between high-, emerging, and low-income countries.

This type of analysis is not new either; many states and regions in the United States have used innovation ecosystem mapping to create new economic growth opportunities, inform better policymaking, and develop new technologies and companies.[170] But it is unlikely individual countries will conduct this type of mapping on their own without high-level coordination, particularly low-income countries. Furthermore, the data collected must be consistent across countries, which is best facilitated by a single coordinating organization. Of course, the IEA only directly supports its member countries that provide its funding, so such an effort should be supported by international organizations, such as the World Bank or regional development banks.

The IEA Should Develop Clean Energy Innovation Agreements to Demonstrate New Technologies

To coordinate high-income countries' investments in RD&D with low-income countries' willingness to host clean energy pilot and demonstration projects, IEA should implement "Clean Energy Innovation Agreements," modeled on the Agency's "Technology Implementing Agreements," which encourage task- and cost-sharing of research priorities for specific technologies like nuclear fusion end-use efficiency, renewables, hydrogen, and cross-cutting technologies between high-income countries.[171] These agreements should be revised or complemented to also include low-income countries aiming to expand clean energy access by hosting projects that pilot and demonstrate breakthrough clean energy technologies—with strong and proper IP protections—that otherwise would struggle to advance from the

lab bench in high-income countries. If properly executed, low-income countries would be able to support advancing next-generation clean energy, while also benefiting from the relevant experiences and resources of high-income countries, while high-income countries would have an additional pathway to advance homegrown innovations that would typically languish.[172]

Combat Green Mercantilist Practices to Enhance Global Innovation

Many emerging countries, like China and India, have implemented green mercantilist practices that attempt to out-subsidize—rather than out-innovate—other countries to gain economic benefits.[173] The result is cheaper clean energy in the short term, but stifled clean energy innovation in the long term because there is no incentive for entrepreneurs, innovators, or new firms to enter the market against unfairly subsidized competitors. If high-income countries and international institutions are serious about addressing climate change, they must combat unfair mercantilist trade practices such as illegal subsidies, compulsory licensing, and forced localization policies.

High-Income Countries Should Combat Mercantilism Through Tariffs and Trade Agreements

In absence of emerging countries unilaterally forgoing green mercantilism, high-income countries should combat green mercantilism to the fullest extent, particularly in emerging economies. In the short term, this may mean tariffs on products exported unfairly by mercantilist countries. For instance, efforts by the United States to curtail unfair use of below-market subsidies and forced localization policies in China and India is a good step toward leveling the playing field for all countries' clean energy companies to compete.

In the medium term, high-income countries should also move beyond tariffs to combat green mercantilist policies through trade negotiations. One option is to establish a Clean Technology Agreement (CTA) based on the Information Technology Agreement (ITA) established in 1996. The ITA gradually eliminated all tariffs on designated information and communication technology products, which have undoubtedly increased ICT trade and investment around the world and driven innovation in the sector. Similarly, a CTA would expand global clean technology trade by eliminating tariffs in exchange for green mercantilists ending their unfair trade policies. Companies would compete on their technological merits, allowing innovative firms to reinvest in more RD&D to develop even better clean energy technologies and drive down costs. And it would also reduce growing clean energy trade tensions and provide an avenue for negotiating a tariff-free global clean energy market.

The UN Should Discourage Green Mercantilism in International Climate Negotiations

The UN plays a central role in coordinating international climate talks. Instead of allowing compulsory licensing to continue to grow as an issue, it can make innovation a priority. To do so, the UN should work to facilitate negotiations through the UNFCCC process on an international climate agreement that doesn't include compulsory licensing or assume clean energy falls under the Doha Declaration of the TRIPS agreement, as it pertains to addressing climate change. This shouldn't preclude international support for low-income countries looking to alleviate severe energy poverty; rather, the UN should not tacitly allow countries to boost domestic industries through compulsory licensing under the guise of climate mitigation and at the cost of long-term carbon reductions.

The World Bank Should Shift Partial Funding Away from Green Mercantilist Countries

The World Bank should begin providing green mercantilists a disincentive for continuing their globally harmful clean energy policies. The Bank should immediately stop funding projects that include provisions

for compulsory licensing or domestic content requirements. This would immediately empower clean energy projects to use the most innovative and affordable technologies available. The Bank should also announce its intention to shift some financing away from green mercantilist countries and toward low-income countries that do not utilize mercantilist policies. The shift in funding should not impact least-developed countries and it should not eliminate funding for a particular country. Instead, the shift in financing would recognize that countries that use harmful green mercantilist policies are unable to maximize their support from the World Bank and its affiliated funding mechanisms.

Support Innovation-Based Energy Access to Address Climate Change and End Energy Poverty

Previous attempts to address energy access and rural poverty around the world have myopically focused on deploying energy-efficient technologies, solar lamps, battery charging stations, or micro-grids that provide limited energy services to low-income populations. These initiatives—which certainly have useful applications for improving human well-being—are unfortunately still not to scale with low-income countries' energy poverty needs. A new focus on clean energy innovation provides a realistic path toward providing energy access and decreasing carbon emissions at a meaningfully global scale.

The UN Should Properly Define "Modern Energy Access"

The UN SE4ALL initiative should explicitly include improving energy access in a modern context equivalent to what high-income countries benefit from today.[174] Doubling or tripling energy consumption in energy-poor countries means little when the gap in energy consumption per capita between high- and low-income countries is actually more on the magnitude of one hundred instead of one. For example, rather than meeting the IEA's low estimate of what constitutes modern energy access—100 kWh per capita, per year—the UN should work toward raising low-income countries' energy consumption to that of, say, Japan (7848 kWh per capita, per year), which has a high standard of living but is also a leader in energy efficiency.[175] By focusing on a much lower—and less prosperous—energy access goal, the UN is supporting small-scale solutions with limited long-term impacts. While small technology solutions like solar lanterns are important, the UN should think bigger and elevate the international energy access debate toward a much more humane and prosperous goal that is in line with the high levels of energy access high-income countries benefit from today.

The World Bank Should Finance the Most Affordable Technology Options In Low-Income Countries

Many low-income countries with very little access to energy continue to use oil, gas, and coal to meet development needs when hydroelectric and geothermal resources are unavailable, and when renewable or nuclear energy is too expensive. With climate mitigation in mind, the World Bank and other international institutions have pledged to reduce fossil fuel consumption and minimize lending for coal-fired generation. However, as Scott Morris and Billy Pizer of the Center for Global Development argue, "IDA-only countries generally lack alternative means of financing their energy needs. These countries should neither be hindered in their access to energy resources necessary for economic development, nor mistakenly led to invest in coal-fired capacity that is a less economical choice."[176] The World Bank's IDA lending program should continue to make credit available to low-income countries for developing energy-generating systems that are the most affordable option, even if they are fossil fuel-based. International institutions should not limit global economic development and energy access in the name of climate mitigation, or offer more expensive energy options when cheaper sources are available.

CONCLUSION

Addressing climate change is a global imperative every year, but the remainder of this decade is particularly critical. In many ways, advancing effective climate policies between now and 2020 will dictate whether the world truly addresses climate change before it is too late.

By 2015, the momentum of current global climate negotiations will either result in another modest, unenforceable set of carbon targets or no agreement at all. High-income and emerging countries are already wrestling with the rapidly increasing costs of clean energy deployment subsidies, the ineffectiveness of modest carbon prices, the inadequacy of too-low carbon caps, and the long-term challenges of mercantilist trade policies. And low-income countries are already being impacted by the changing climate, yet are struggling to understand their role in solving it while simply trying to gain basic access to energy. A climate policy pivot is desperately needed.

An innovation-based approach offers such a pivot. The policies proposed in this report offer a new start in global climate policy. They recognize that, at its core, climate change is a technology problem requiring global solutions that advance low-carbon technology options that cost no more than fossil fuels. We simply cannot set a target or price or subsidy and hope for the best. We have pursued that approach for 20 years with little to show for it. With time running out, it is now or never to get serious about implementing an aggressive clean energy innovation policy.

SUMMARY OF POLICY REFORMS

For too long international climate policy has been focused on carbon targets, pricing, and subsidies to drive the deployment of existing clean energy technology in the name of climate change mitigation. Unfortunately these efforts have not made a dent in the challenge—global carbon emissions have grown faster since 2000 (2.2 percent per year) than from 1970 to 2000 (1.7 percent per year) with no signs of abating. Perpetuating these failures in the next round of climate negotiations is unacceptable.

The primary goal of climate policy should be to make the unsubsidized cost of clean energy cheaper than fossil fuels. To do this requires significant investment in innovation of better technologies—not just dependence on deployment—which requires substantial reforms to national and international approaches to climate and energy policy. The following is a summary of the proposed policy reforms to enhance international energy innovation capacity to confront global climate change.

Reforms for High-Income Countries

- Countries should be offered the option within global climate negotiations to meet increasing government clean energy RD&D intensity targets in lieu of, or as a complement to, meeting carbon emission targets.
- Countries should adopt "revenue-raising" policies, such as a modest carbon tax or oil and gas drilling fees, and direct the revenue toward clean energy innovation programs.
- Countries should eliminate subsidies for mature fossil fuel technologies and redirect those savings toward supporting clean energy innovation programs.
- Countries should support smart clean energy deployment by implementing performance-based subsidies or incentives that steadily decrease over time, requiring technologies to compete on technological merit and innovation, not government largesse.
- Countries should combat green mercantilism with tariffs on mercantilists' products in the short term and also work toward international trade agreements on clean energy technologies that remove domestic protectionist policies and level the global playing field.

Reforms for Emerging and Low-Income Countries

- Countries should be offered the option within global climate negotiations to meet increasing government clean energy RD&D intensity targets in lieu of, or as a complement to, meeting carbon emission targets.
- Countries should adopt "revenue raising" policies, such as a modest carbon tax or oil and gas drilling fees, and direct the revenue toward clean energy innovation programs.
- Countries should coordinate with high-income countries and international institutions to facilitate clean energy test-bed, demonstration, and smart deployment projects.
- Countries should avoid resorting to green mercantilist practices in favor of a strong global innovation ecosystem.

Reforms Requiring IEA Action

- The IEA should coordinate an energy innovation ecosystem mapping initiative for low-income and emerging economies to inform better international clean energy innovation collaborations for developing technology test-beds and facilitating smart deployment.

- The IEA should implement "Clean Energy Innovation Agreements," modeled on the Agency's "Technology Implementing Agreements," to encourage low-income countries to test, pilot, and demonstrate emerging technologies.

Reforms Requiring UN Action

- The UN should recommend in the next climate negotiations the inclusion of an option for countries to commit to an energy RD&D investment target in lieu of, or as a complement to, meeting carbon emission targets.

- The UN should facilitate affordable clean energy innovation-based technology leapfrogging in low-income countries, where possible, as a chief method of achieving energy access and mitigating climate change.

- The UN should work to facilitate negotiations through the UNFCCC process on an international climate agreement that doesn't include compulsory licensing or assume clean energy falls under the Doha Declaration of the TRIPS agreement.

- The UN's SE4ALL initiative should explicitly include improving energy access in a modern context equivalent to what high-income countries benefit from today.

Reforms Requiring World Bank Action

- The World Bank should use its IBRD policy loans to support the implementation of clean energy innovation policy strategies in lower-middle income and emerging countries, moving beyond carbon prices, targets, and subsidies.

- The World Bank should influence the redesign of the Clean Technology Fund to represent the premier "clean energy innovation" financial mechanism for low-income and emerging countries to coordinate the testing and demonstration of advanced clean energy technologies.

- The World Bank should immediately stop funding projects that include provisions for compulsory licensing or domestic content requirements and also shift partial funding away from countries that practice green mercantilist policies and toward countries that do not.

- The World Bank should use its IDA lending program to continue to make credit available to low-income countries for developing energy-generating systems that are the most affordable option, even if they are fossil fuel-based.

APPENDIX: CHARACTERIZING COUNTRIES BY INCOME

To distinguish between high-income and low-income countries, the World Bank Atlas method for defining income standing was implemented.[177] The World Bank classifies countries into four income groups: low income, lower-middle income, upper-middle income, and high income, based on their 2012 gross national income per capita.[178] The income groups are determined as follows:

- Low income: $1,035 or less
- Lower-middle income: $1,036 - $4,085
- Upper-middle income: $4,086 - $12,615
- High income $12,616 or more

For the purposes of this analysis, the BRIC countries (Russia, Brazil, India, China, and South Africa) were separated from the other income groups. These countries are uniquely positioned emerging economies, and as such their circumstances suggest alternative potential to impact international energy policy, setting them apart from their conventional income classifications. The five income groups below reflect this report's classification of countries.

Low	Lower-Middle	BRICS	Upper-Middle	High
Afghanistan	Armenia	Brazil	Albania	Antigua & Barbuda
Bangladesh	Bhutan	Russia	Algeria	Australia
Benin	Bolivia	India	Angola	Austria
Burkina Faso	Cameroon	China	Azerbaijan	Bahamas
Burundi	Cape Verde	South Africa	Belarus	Barbados
Cambodia	Congo, Rep.		Bosnia & Herzegovina	Belgium
Central African Republic	Cote d'Ivoire		Botswana	Bermuda
Chad	Egypt, Arab Rep.		Bulgaria	Canada
Comoros	El Salvador		Colombia	Chile
Congo, Dem. Rep.	Georgia		Costa Rica	Croatia
Eritrea	Ghana		Dominica	Cyprus
Ethiopia	Guatemala		Dominican Republic	Czech Republic
The Gambia	Guyana		Ecuador	Denmark
Guinea	Honduras		Fiji	Equatorial Guinea
Guinea-Bissau	Indonesia		Gabon	Estonia
Haiti	Kiribati		Grenada	Finland
Kenya	Kosovo		Hungary	France
Kyrgyz Republic	Lao PDR		Iraq	Germany
Liberia	Lesotho		Jamaica	Greece
Madagascar	Mauritania		Jordan	Iceland
Malawi	Micronesia, Fed. Sts.		Kazakhstan	Ireland
Mali	Moldova		Lebanon	Italy
Mozambique	Mongolia		Macedonia, FYR	Japan
Nepal	Morocco		Malaysia	Korea, Rep.
Niger	Nicaragua		Maldives	Latvia
Rwanda	Nigeria		Marshall Islands	Lithuania
Senegal	Pakistan		Mauritius	Luxembourg
Sierra Leone	Papua New Guinea		Mexico	Malta
Tajikistan	Paraguay		Montenegro	Netherlands
Tanzania	Philippines		Namibia	Norway
Togo	Samoa		Palau	Poland
Uganda	Sao Tome & Principe		Panama	Portugal
Zimbabwe	Solomon Islands		Peru	Puerto Rico
	Sri Lanka		Romania	Singapore

Low	Lower-Middle	BRICS	Upper-Middle	High
	Sudan		Serbia	Slovak Republic
	Swaziland		Seychelles	Slovenia
	Timor-Leste		St. Lucia	Spain
	Ukraine		St. Vincent & the Grenadines	St. Kitts & Nevis
	Uzbekistan		Suriname	Sweden
	Vanuatu		Thailand	Switzerland
	Vietnam		Tonga	Trinidad & Tobago
	Yemen, Rep.		Tunisia	United Kingdom
	Zambia		Turkey	United States
			Turkmenistan	Uruguay
			Tuvalu	
			Venezuela, RB	

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ABOUT CCEI

The Center for Clean Energy Innovation is a Washington, D.C.-based think tank dedicated to designing, advocating, and advancing cutting edge energy innovation policies to address global climate change, increase economic growth, and provide universal energy access. Founded in 2014, CCEI is a non-partisan organization that accepts climate change as an innovation challenge at heart, focusing on energy RD&D policy, smart deployment, clean technology trade policy, STEM education and training, and advanced manufacturing at the state, national, and international levels.

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