

# **THE ROLE OF TECHNOLOGY POLICIES IN AN INTERNATIONAL CLIMATE AGREEMENT**

## **Issue Paper**

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Achieving long-term climate change policy goals will require a remarkable ramp-up in the innovation and deployment of energy-efficient and low-carbon technologies. This technological transformation must occur in an environment that is already experiencing substantial increases in investment. The International Energy Agency forecasts more than \$20 trillion of investment in the global energy infrastructure between now and 2030. Some of this accelerated investment is evident in China, where one out of six coal-fired power plants is less than three years old. But the investment is not universal; populations in least developed countries still suffer from lack of access to power and basic energy poverty that can inhibit advances along a variety of development measures.

Transitioning away from fossil fuels as the foundation of industrialized countries and as the basis for development in emerging economies and least developed countries necessitates a suite of policies to provide the proper incentives for technological change. These policies will drive invention, innovation, commercialization, diffusion, and utilization of climate-friendly technologies. Altering the orientation of \$1 trillion per year in energy investments is no small task: the UNFCCC Secretariat recently estimated that investment in emission mitigation will need to be on the order of \$200 billion annually by 2030 to return global emissions to current levels. The critical role of developing and deploying climate-friendly technologies has drawn more attention to the impact of three categories of policies addressed in the three main sections of this paper: (1) international carbon markets; (2) technology transfer to developing countries; and (3) coordinated innovation and commercialization programs.

## 1. CARBON MARKET IMPACTS ON TECHNOLOGY

### *1.1 Cap-and-Trade Programs*

Carbon markets continue to emerge around the world and will likely play the primary role in emission mitigation policies in developed countries. Cap-and-trade programs, like the EU Emission Trading Scheme, have received substantial interest among policymakers in the United States, Australia, Japan, and other countries. Emission reduction credit programs, such as the Clean Development Mechanism (CDM), effectively extend the reach of cap-and-trade by financing emission mitigation projects in developing countries. These efforts implicitly set a price on emitting greenhouse gases and, by raising the price on conventional fossil fuels and energy-intensive production practices, induce investment in less emission-intensive technologies.

Given the long lifetimes of emission-intensive capital – power plants may operate 50 years or more, building shells may last 100 years – long-term carbon price signals may be necessary to allow the owners of such capital to form appropriate expectations and alter the nature of their investments. Extending the time horizon of cap-and-trade programs – including the January 2008 energy and climate package announcement regarding the EU ETS – can send

price signals that will drive more innovation because firms will expect a market for these lower-carbon technologies. Blunt policy instruments such as performance standards or bans of carbon-intensive products can also induce innovation, but such approaches are typically less economically efficient. Interest in long-term certainty over carbon prices has motivated some in the U.S. to call for targets through 2050 to provide regulatory certainty. This may also suggest the value in designing cap-and-trade programs to deliver more predictable carbon prices through various cost-containment measures, such as banking and borrowing or a safety valve.

## ***1.2 Clean Development Mechanism***

Pricing carbon can leverage foreign direct investment to promote less carbon-intensive development. For example, the Clean Development Mechanism grants emission reduction credits for projects in developing countries that reduce emissions relative to a hypothetical business-as-usual baseline for use by firms covered by cap-and-trade programs in developed countries. Some of the CDM projects have resulted in the deployment of renewable power, such as wind farms, as an alternative to coal-fired power generation. Some have criticized the CDM for projects based on minor process modifications that do not involve substantial investment in new technologies, such as the manufacture of fluorinated refrigerants. Some countries may also consider CDM participation a substitute for taking further emission mitigation efforts or even use the CDM to justify weakening policies in other areas.

Reforming the CDM could facilitate more substantial transfers of technology. Creating a list of pre-approved technologies could lower the transaction costs of the review and certification process, and thus encourage more projects. Expanding the coverage of the CDM from specific projects to an entire industry, such as the power sector, could promote the exploitation of all low-cost mitigation opportunities in that country's industry, some of which may be too small to be proposed on a project-by-project basis. Modifying the CDM to include policies, as well as projects, could also stimulate further investment in low-carbon technologies. For example, credits could be awarded for implementing fuel economy standards, lowering fossil fuel subsidies, or enforcing land tenure rules that slow deforestation.

Three key challenges confront the continued use and possible improvement of the CDM as a means for moving climate-friendly technologies to developing countries. First, the difficulty in constructing a project-based counterfactual – what would emissions have been in the absence of the project – merely becomes a similar industry- or policy-based counterfactual estimation problem. What would emissions have been in the absence of the sectoral CDM or the policy-based CDM effort? Second, the price for CDM credits will reflect the demand from developed countries' cap-and-trade programs. Several proposals in the EU and the United States would place a limit on the volume of CDM credits that could enter their carbon markets. These proposed import quotas could lower the credit price and discourage some new technology investment. Third, the CDM may provide a disincentive for some emerging countries to take on more substantial action domestically or make commitments in an international agreement. Why would these countries risk incurring costs by committing to specific emission goals or mitigation policies, when they can participate voluntarily through the CDM? It is the potential for more substantial action and commitments that could drive even more technology transfer, with the appropriate domestic implementation policies.

### ***1.3 Moving Beyond Carbon Pricing***

Perfecting the Clean Development Mechanism would not be sufficient to promote the development and diffusion of climate-friendly technologies. Putting a price on carbon may not facilitate new investment flows and associated transfer of technology in developing countries with weak market institutions. If a country has difficulty attracting capital generally, changing the relative prices of carbon-intensive and carbon-lean capital will not resolve this problem. This would require additional policy efforts to stimulate the transfer of technology to developing countries (addressed in section 2).

While putting a price on carbon will draw more resources into low-carbon technology research and development (R&D), this will not tackle the general disincentive for the private sector to invest in R&D. Undertaking R&D effectively produces new knowledge, and this knowledge is a classic public good. Once a firm produces this knowledge, it is difficult to prevent others from benefiting from the knowledge (although patent law provides some protection). Since the innovating firms cannot capture all of the benefits of the R&D, they tend to under-invest in such activities. This requires additional policy efforts to promote innovation in the public and private sector to ensure that the next generation of climate-friendly technologies is available for deployment (addressed in section 3).

## **2. PROMOTING TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES**

Adequately meeting the challenge of climate change will require substantial emission mitigation in developing countries over the 21<sup>st</sup> century. The majority of forecast greenhouse gas emissions will occur in these countries, and efforts to stabilize atmospheric concentrations at levels called for by some scientists are not feasible without developing country emission mitigation. The need to locate substantial emission mitigation in emerging and developing countries will require transfers of resources and technologies from the developed world. We review several means to promote technology transfer: through implementing clean technology funds; by exporting good policy practice and building capacity to absorb new, lower-carbon technologies; and by addressing intellectual property rights.

### ***2.1 Clean Technology Funds***

The 1992 UN Framework Convention on Climate Change calls on developed countries to finance the transfer of technology to developing countries. This builds on the model established by the Multilateral Fund under the Montreal Protocol to support developing countries' efforts to reduce their emissions of ozone-depleting substances. After a modest record of financial assistance for such activities through the Global Environmental Facility, several developed countries, including Japan, the United Kingdom, and the United States, stepped forward this year to pledge billions of dollars for technology transfer. These pledges have focused more attention on the potential for direct government support of investment in mitigation technologies in developing countries, and raise important questions about how to implement such funds.

The mechanism for allocating resources from the clean technology fund should reflect the fact that a market-based mechanism – the CDM – already exists to move some technology to (some parts of) the developing world. The clean technology fund should complement, not substitute, for efforts that would occur otherwise through existing markets. This suggests that the fund could focus on financing technologies that may present a combination of high risk and high return, but whose risk may discourage private investors. The fund may also want to support the types of technologies that may expect rapid improvements (for example, in quality and costs) through learning-by-doing, where real-world experience with the technology is crucial to establishing a broader market presence. Finally, in order to avoid subsidizing investments that would have occurred anyway, the fund could focus primarily on technologies that would not be economic in the absence of climate change policy. This would distinguish an investment in carbon capture and storage (CCS) at a coal-fired power plant, for which there is no economic reason except to address climate change, from an investment in a more efficient coal-fired boiler, for which an increasing cost of coal could justify. The fund could finance technologies across a continuous spectrum based on their potential profitability in the absence of policy intervention, starting with the unprofitable extreme, where CCS would lie. The next set of technologies on this spectrum could include high-cost renewables, such as on-grid solar, that typically may not be economic in the absence of policy (for example, feed-in tariffs or carbon prices).

The centralized nature of the fund, in contrast to the atomized CDM and private markets, also highlights an opportunity to make investments that can maximize the mitigation potential for a given amount of resources. Specifically, the clean technology fund could address criticisms of the CDM that it has created windfall profits for some firms, by financing projects at a level sufficient to provide a modest, but not an inordinate, profit for the developing country firm. A reverse auction could be one vehicle for allocating the fund's resources. Under such a mechanism, the fund would solicit bids from firms in developing countries. The bids would represent the amount the firm would require in a subsidy in order to invest and use a new, climate-friendly technology. The fund could start with the lowest cost bids and work up the bid profile until it has exhausted all the resources dedicated for the specific technology auction. The challenge in effectively implementing a reverse auction lies in identifying technologies and projects that are low-cost but would not have happened in the absence of the fund.

Financing clean technology funds may run against a variety of political difficulties. Some developed country governments may not appropriate revenues to subsidize investment in climate-friendly technologies in developing countries while firms in their own countries must incur costs to comply with domestic emission mitigation regulation, such as a cap-and-trade program. Some governments may not offer much assistance simply because of existing fiscal constraints, especially those facing long-term, structural deficits as a result of government pension and health care programs. Some developing countries have expressed concern that clean technology funds, instead of attracting new resources to development, could draw resources from existing official development assistance commitments, effectively reallocating development support from current projects to climate-oriented technology projects. Dedicating a fraction of revenues generated from developed countries' domestic emission mitigation programs – such as from an auction under a cap-and-trade regime or from a carbon tax – could allay concerns of developing countries and circumvent some of the political opposition to government

appropriations for what would appear to be foreign assistance. Regular review of the contributions by developed countries also may address this issue of developing countries, and resolve concerns that the peers within the OECD are making comparable financial commitments to the fund.

## ***2.2 Exporting Good Policy Practice and Building Capacity***

Developed and emerging economies both have substantial experience in implementing policies that can affect the investment in more energy-efficient or low-carbon technologies. Drawing lessons from these successes and failures can inform the design of new policies in all countries, but especially those in emerging and developing countries that may lack the institutional capacity to fully evaluate and compare all policy options. Establishing a set of “best practice” policies can draw from past efforts to promote the deployment of energy-efficient technologies, and tailor guidance for countries’ specific economic and cultural circumstances.

The initial set of “best practice” policies should focus on promoting no regrets and low-cost measures. This would draw attention to policies that facilitate investment in more energy-efficient technologies, since they deliver a stream of returns over time in terms of lower expenditures on fuel and power. It could also highlight opportunities for countries to address multiple policy objectives, such as climate change mitigation *and* local air quality improvement or climate change mitigation *and* energy security. These efforts should also consider means to promote the diffusion of technologies to facilitate adaptation to climate change.

Consider the example of reforming energy subsidies. Removing subsidies on the consumption of energy and the production of fossil fuels could significantly affect carbon dioxide emissions in a number of developing and emerging economies. The United Kingdom demonstrated in the 1990s the effect on carbon dioxide emissions of reducing subsidies on coal during its “dash for gas.” The International Energy Agency’s analyses of energy subsidies have consistently shown how subsidy removal could lower emissions by 10 percent or more (and in some cases, much more) in large developing countries. Such efforts would free up fiscal resources that could finance other socially-desirable activities. Phasing out subsidies could yield comparable price changes on energy as imposing cap-and-trade programs in developed countries, and deliver economic benefits by stimulating a more efficient allocation of investment that can accelerate economic growth. Reducing energy consumption, especially of fossil fuels that contribute to smog and particulate matter pollution, could improve urban air quality.

Some governments may balk, however, at a proposal to remove energy subsidies. In some countries, energy subsidies serve as in-kind support for the poorest households as part of the social safety net. Also, concentrated interests, especially among businesses that benefit from subsidies, may challenge efforts to reform the pricing of energy. Freeing up resources through subsidy removal could provide flexibility for governments to address these concerns. For example, the government could substitute food aid or direct financial support for subsidized kerosene or heating oil to low-income households. Some countries may implicitly subsidize energy use because they lack the necessary physical infrastructure, such as metering of consumption, or they lack institutional capacity to regularly process bills and payments for delivery of energy. Further assistance in improving basic capacity will be necessary in these

cases. And of course, some energy subsidies – such as for renewable power – are beneficial for the climate.

### ***2.3 Addressing Intellectual Property Rights***

Firms that have commercialized energy-efficient and low-carbon technologies in developed countries may be reluctant to sell their technologies to developing countries out of concern that they may suffer from patent infringement and associated violation of intellectual property rights (IPR). The IPR issue plus the fear that developing countries will not allocate substantial resources to purchase climate-friendly technologies may seriously discourage private sector R&D activities. One possible remedy would be to follow the example evident in international public health efforts to finance the development and subsidize the dissemination of a malaria vaccine in developing countries. Several important issues differentiate the malaria vaccine from the need for climate-friendly technologies. First, the challenge of malaria requires a “silver bullet” – a single vaccine (or a series of related vaccines to confront biological resistance) – while some have described the technology challenge in the climate context as necessitating “silver buckshot” – a large number of innovations across an array of economic activities. Second, the scope of the investment problem under climate change likely dwarfs that for malaria. To remedy malaria may require tens of billions of dollars, while the climate policy challenge lies in torquing the trillions of dollars of energy investment expected over the next several decades. If a clean technology fund or the returns from market-based mechanisms are not sufficient to compensate developed country firms for investing in new technologies, then the public sector in the developed world could step forward to underwrite more R&D.

## **3. COORDINATING POLICIES ON TECHNOLOGY INNOVATION AND COMMERCIALIZATION**

The transition to a low-carbon and eventually zero-carbon economy will require substantial innovation to lower the costs of existing technologies and to develop and commercialize new technologies. Public sector research and development can support these efforts, and coordination among large developed and emerging economies could ensure more substantial funding and efficient allocation of R&D activities.

### ***3.1 Global Climate R&D Fund***

Public sector investment in energy and climate-related R&D has fallen considerably since the early 1980s. Substantially increasing resources for such R&D, especially for the basic science that will underlie future commercial technologies, would complement policies to mitigate greenhouse gas emissions. Increasing public sector R&D provides an opportunity for the developed and emerging economies to coordinate their efforts. Emerging countries have sufficient resources and human capital to contribute to this task. It is also important to engage emerging economies because they can focus some of the R&D activity to ensure that it can support new technologies appropriate for the institutions and norms in developing countries.

Such a global climate R&D fund could be a “virtual” fund. It would not require the creation of a new institution to collect and disburse monies for research. Some countries may not be enthusiastic about sending billions of dollars annually for R&D to an international institution in which they may have little influence on the allocation of those funds. Instead, the virtual fund could serve as a means for focusing attention on the pledges and delivery of funds to R&D on climate-friendly technologies. It could compile information on technology R&D programs – funding levels, types of projects, R&D outcomes, etc. – and periodically summarize and review these efforts to ensure that countries live up to their pledges and to identify opportunities for R&D complementarities and coordination. The virtual fund could also serve as the mechanism for coordinating participation in large-scale, high-risk R&D enterprises, not unlike the multi-national ITER nuclear fusion project or the international space station.

### ***3.2 Supporting Innovation***

To support innovation in the basic and applied sciences to increase the knowledge base necessary to develop new, commercial climate-friendly technologies, countries could coordinate their R&D portfolios to minimize redundancy, to cover all necessary technological bases, and to exchange information gained through national-level R&D processes. This coordination could cover the allocation of effort by government scientists and engineers, the targeting of extramural research funding to specific projects, and public-private partnerships.

The global climate R&D fund could also explore more innovative ways of allocating resources to promote the development of new technologies. For example, the fund could support various R&D competitions, in which large prizes would be paid out for the first research team to develop a technology or product that satisfies the relevant evaluation criteria. For example, the United States employed such a competition for super-efficient, CFC-free refrigerators in the 1990s. The X-Prize Foundation supported such a competition for private firms to build a spacecraft in 2004. The appeal of a competition is that the fund only pays out for successful outputs, in contrast to the standard model of financing R&D inputs.

### ***3.3 Financing Demonstration Projects***

Bringing new ideas to full commercialization often presents challenges, and for some new technologies, the private sector may not undertake the risks necessary to bring them to market. Since some of the economic risk the private sector faces reflects uncertainty about future climate change policies and the incentives they would provide to private investments, the government may have a role in financing demonstration projects. The case for such demonstration projects may be even stronger in developing and emerging economies where incomplete markets may undermine investment in commercializing these technologies.

Examining the potential for CCS at power plants may serve as an excellent opportunity for a coordinated, international demonstration project. A number of countries with large coal reserves – such as the United States, China, India, South Africa, Australia, Poland, and Germany – may find such a project beneficial because it could provide an avenue for continued use of a domestically-produced fuel without adverse climate impacts. A coordinated program of CCS demonstration projects may also provide additional information on storage efficacy in different

parts of the world that vary in their sub-surface geology. The set of CCS projects could also test a variety of capture technologies, and evaluate their performance with different types of coal-fired power plants, including pulverized coal and gasification facilities. A substantial demonstration project may also highlight opportunities for reducing costs (and energy consumption) of CCS technology, that would make it more appealing as a mitigation option.

#### **4. THE ROLE OF TECHNOLOGY POLICY IN THE POST-2012 INTERNATIONAL CLIMATE AGREEMENT**

The next international climate agreement can provide several mechanisms to facilitate the development and deployment of climate-friendly technologies. First, the agreement can provide a venue for countries to pledge resources for technology transfer and for R&D activities. The agreement could also codify such pledges as commitments, on par with commitments to limit emissions as in Annex B of the Kyoto Protocol. In reaching agreement on these financial commitments, developed and emerging countries would explicitly express their means for meeting these commitments to promote credibility and trust in the agreement. This could take the form of identifying a specific revenue stream (for example, auction revenues from a cap-and-trade program) that would be adequate and reliable for supporting financial pledges.

Financing technology transfer will require coordination and agreement on the principles for allocating resources. An institutional home for clean technology funds may be necessary, and the international policy community will need to decide whether to centralize such efforts in a new institution or an existing international institution, or manage the program through a decentralized array of national institutions. Likewise, some agreement on the means for coordinating R&D activities will require consideration of institutional design.

An independent, review mechanism of policies that affect technological development and deployment may benefit these efforts. Rigorous, third-party review of all nations' policies and financing could provide a strong foundation for coordinated, international efforts by providing an authoritative assessment of the comparability of effort among participating countries. This could include reviews of financial contributions by large countries, analyses of the effectiveness of technology transfer activities, and assessments on the implementation of best policy practices around the world. Such reviews could be undertaken by an existing international institution, or may require the creation of a new, professional bureaucracy with this single, surveillance task. Such an effort could also complement assessments of the comparability of effort on mitigation, adaptation, and other elements of the international agreement.

Finally, the international climate policy architecture could provide positive incentives for developing and emerging countries to pursue good policy practice. For example, conditioning access to climate technology funds on the implementation of domestic "no regrets" climate policies could substantially increase the "climate return" for the technology funds' resources. Alternatively, the clean technology funds could scale access to the extent of policy action in developing and emerging economies – as they undertake more policies to facilitate more climate-friendly development, they can access even more resources. Such a reward for good policy actions would build on the independent, expert review of countries' climate and energy policies.