Global Green Growth Institute

Global Economy and Development at BROOKINGS

Green Growth Innovation: New Pathways for International Cooperation

[Nathan Hultman, Katherine Sierra, Jason Eis, Allison Shapiro]

Nathan Hultman is director of the Environmental Policy Program at the University of Maryland School of Public Policy, and a non-resident fellow in the Global Economy and Development program at the Brookings Institution.

Katherine Sierra is a senior fellow in the Global Economy and Development program at the Brookings Institution.

Jason Eis is the deputy director in the London Office of the Global Green Growth Institute.

Allison Shapiro is a fellow for the Erb Institute for Global Sustainable Enterprise at the University of Michigan.

Acknowledgements:

The Brookings Institution is a private non-profit organization. Its mission is to conduct high-quality, independent research and, based on that research, to provide innovative, practical recommendations for policymakers and the public. The conclusions and recommendations of any Brookings publication are solely those of its author(s), and do not reflect the views of the Institution, its management, or its other scholars.

Support for this publication was generously provided by the Global Green Growth Institute and the Government of Norway. The authors would also like to thank our outside expert advisors—José Goldemberg, Romain Murenzi, and Anand Patwardhan—who provided very helpful comments on drafts of this report. Their comments and guidance are greatly appreciated. We are also grateful for discussions with Al Watkins, Jonathan Coony, Nigel Purvis, Mark Dutz, Rick Duke, Robert Marlay, Charles Ebinger, Joe Bradley, Mark Wu and Richard Samans. All mistakes are, of course, our own. Additionally, we would like to thank Claire Langley for her research and writing support and Kirsten Gilbert for editorial support.

Brookings recognizes that the value it provides is in its absolute commitment to quality, independence and impact. Activities supported by its donors reflect this commitment and the analysis and recommendations are not determined or influenced by any donation.

Cover Photo: © Greenpeace / Nicolas Fojtu

TABLE OF CONTENTS

FIGURES

ABSTRACT

ACHIEVING GLOBAL GOALS for poverty reduction, economic growth and environmental health will require widespread innovation and implementation of new and appropriate "green growth" technologies. Establishing a sufficiently large suite of innovative options, suitable to all economies, and at the urgent pace required will involve unprecedented innovation activity not only from developed regions, but also from new clusters and enterprises in emerging economies and least developed countries. Stronger international cooperation can play a critical role in facilitating this transformative process. In this paper, we look at areas for new partnerships or cooperation that could most effectively accelerate a green growth transformation. We do this by reviewing the components of a successful innovation "ecosystem," assessing the current status and prospects for green growth innovation, compiling and analyzing existing international initiatives, assessing the needs and pragmatic constraints on international institutions, and recommending an integrated approach to spur global green growth innovation partnerships, especially within developing countries.

I. INTRODUCTION

WE ARE AT a key moment in the evolution of our global approach to the challenges of development, environment and the transition to a green economy. This year marked the 20th anniversary of the U.N. Conference on Environment and Development, also known as the Rio Earth Summit, and the 40th anniversary of the first international meeting to address environment and development in Stockholm. Despite the ambitious and well-intentioned aspirations of these meetings, over 1.3 billion people still do not have access to electricity;[1] 2.5 billion people live without basic sanitation;[2] and 4 billion people live on less than $9 per day.[3] Furthermore, global greenhouse gas (GHG) emissions are likely to exceed the levels that would be needed to maintain the climate at no more than 2 degrees Celsius over pre-industrial levels and some climate impacts are already being felt, with the greatest vulnerabilities in the developing world.

Innovations in green technology represent transformational approaches to these and others of the world's thorniest development and environment challenges. Innovation for green growth has the potential to tackle three challenges simultaneously: encouraging widespread development and poverty reduction; creating new and more vibrant economies based on clean technologies; and securing an increasingly greener world. Importantly, this kind of transformational approach to addressing global development goals through green technologies will require support for innovation across all development contexts. Establishing a sufficiently large suite of technological options, suitable to all economies and at the urgent pace required, will involve unprecedented innovation activity not only from developed regions, but also from new clusters and enterprises in emerging economies and least developed countries. Encouragingly, widespread economic development has increased global capacity for research and development, and created a new tier of emerging innovators in developing countries—and through additional action, we argue that these gains might be bolstered, and additional innovation areas can be encouraged in new regions.

Tackling such challenges as climate change, energy access, environmental degradation, sanitation and water availability while achieving economic and development goals will require unusually creative approaches. The engagement of global innovative capacity depends on effective national innovation systems, and in many places these could potentially benefit from international coordination and support. It will require new and profitable business models, novel approaches to financing, and policy innovations within our national and global institutions.

In this analysis, we seek to elucidate the areas for new international partnerships or cooperation that could be most effective in this transformation. We do this first by reviewing the components of a successful innovation "ecosystem." We then present and analyze a large set of existing international initiatives that aim to support green growth, and identify strengths and gaps in the existing infrastructure. We assess the needs and pragmatic constraints on international institutions, and recommend an integrated, four-part approach to spur innovation partnerships in developing countries. We conclude that, by linking national governments, the private sector, and the international community, a collaborative effort can make concrete improvements in four key green innovation areas:

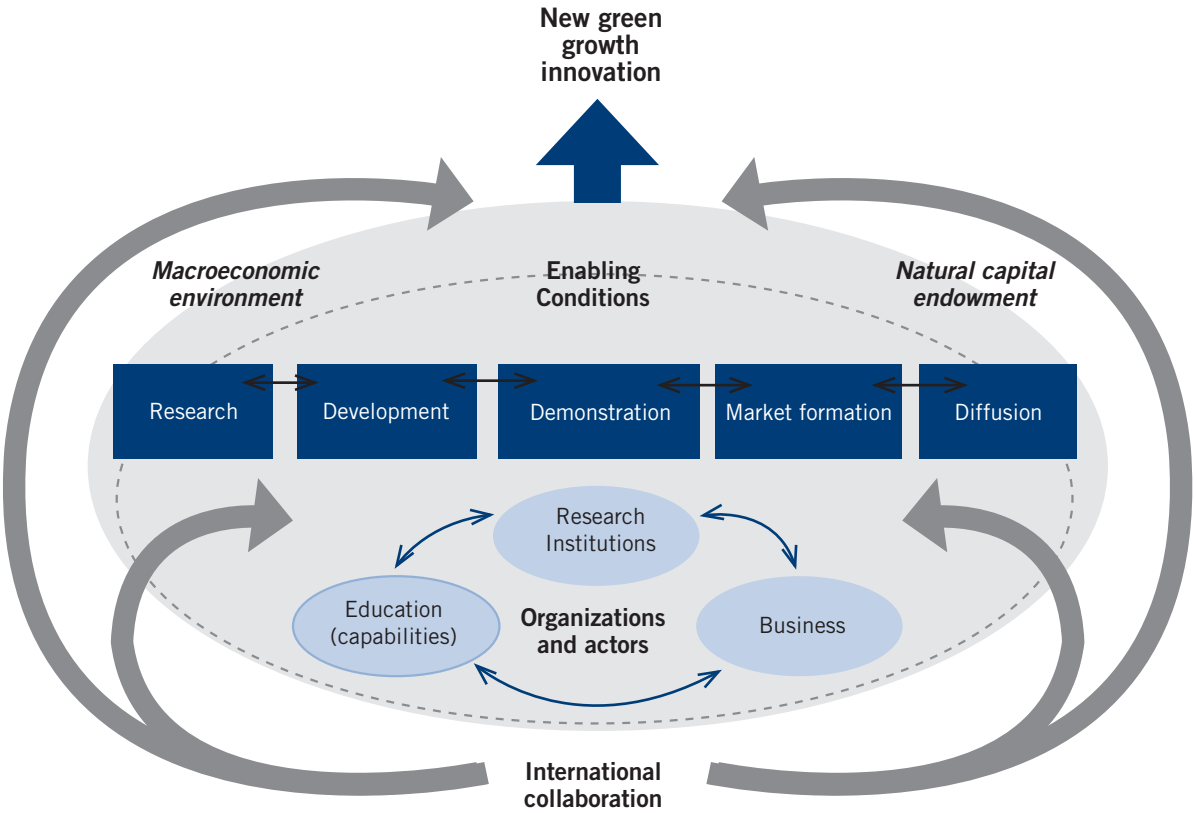
- Cultivating technical knowledge in green technologies;
- Facilitating existing entrepreneurial cultures;
- Providing new models and opportunities for financing and intellectual property sharing; and
- Large scale financing for demonstration and deployment of complex but transformative new technologies.

II. BUILDING INNOVATION ECOSYSTEMS FOR GREEN GROWTH

WHAT IS AN INNOVATION ECOSYSTEM?

THERE ARE MANY ways to characterize innovation. When the term innovation is applied to technological change, it is often conceived of as a change to a product or service—e.g. a higher yielding seed or a more efficient delivery system. However, for the purposes of this paper, the sphere of innovation is defined in broader terms, encompassing significant improvements to goods and services, as well as to operational processes and business models. Furthermore, to facilitate our analysis, we describe innovation in terms of both innovation activities and the innovation ecosystem that supports those activities (Figure 1).

FIGURE 1: NATIONAL INNOVATION ECOSYSTEM



Source: Adapted from: United Nations (2011). World Economic and Social Survey 2011: The Great Green Technological Transformation. United Nations Department of Economic and Social Affairs (UNDESA). NewYork, 2011.

We rely on a standard typography of innovation activity spanning from novel idea generation through to implementation in the economy and society. This continuum can be usefully broken down into four categories: research, development, demonstration and deployment. While innovation activities may look quite different when applied to a new good, as opposed to a new service or organizational structure, this typography emphasizes important commonalities. For example, the research phase (whether for a new material, new financial instrument, or new business model) will be conceptual, with multiple and vague potential applications, and a risk-return ratio inadequate for commercial investors. Similarly, the deployment phase will involve fewer and fewer "significant improvements" compared to the amounts invested as new technologies mature.

All innovative activity involves a creative step—whether radical or incremental, formal or informal. For this paper, it is useful to distinguish between frontier and adaptive innovation activities. Frontier innovation activities are novel solutions that have not yet been introduced to the world. These novel solutions may be either radical or incremental, and are most common during research and development. Adaptive innovation activities involve the application of existing technologies into new contexts. This adoption may be an entirely "off-the-shelf" transfer or it may involve ancillary adaptations. It is most common during demonstration and deployment, and primarily involves "learning by doing". Although the distinction between frontier and adaptive innovation should be seen as relative, at the extremes it helps distinguish pragmatically between the different requirements for "creation" (frontier) vs. "replication" (adaptive).

While countries at all levels of development can engage in all types of innovation activity, higher income countries have historically had far more overall innovation activity, relatively more research and development activity, and more reliance on frontier innovation to drive growth. Similarly, lower income countries have had less overall innovation activity and a relatively greater focus on adaptive innovation. While there is no definitive model for how and how quickly the transition should occur, historic development experience has tended to emphasize the importance of adaptive innovation for developing countries over a relatively long "catch-up" phase. We examine recent trends in green growth innovation in the next section.

Since innovation is a dynamic, unpredictable and uncertain process, it depends critically on creating the right conditions, especially from a policy perspective. Hence, a robust treatment of innovation requires an understanding of the innovation "ecosystem" and its absorptive capacity.

The concept of an innovation ecosystem reflects the individuals and organizations acting and interacting in political, economic and technological systems to catalyze and sustain innovation activity. Its boundaries are amorphous and impossible to control; its interactions are multiple and subject to constant realignment, of a diverse nature, and often intangible. It depends heavily on the effective circulation and communication of knowledge. Innovation to the ecosystem itself is also possible, and can constitute one of the most valuable forms of innovation.

An innovation ecosystem comprises three elements: Actors, organizations (and their facilities), and enabling conditions (formed by the political, economic and technological systems). Actors include the researchers, entrepreneurs, financiers and other individuals doing innovation. Organizations include the universities, research institutions, businesses, knowledge networks, etc. that organize the actors and supporting resources toward specific innovation activities. Cross-organizational enabling conditions include education and training support, direct public funding for innovation, a sufficient legal framework to allow innovators to benefit from their activity, infrastructure (e.g. the internet), and supply-demand mechanisms that communicate economic and social

value. Critical to these enabling conditions is how well they link and align incentives of the innovation actors and organizations, and their activities—for example, the robustness of links between research universities and entrepreneurs to inform the direction of the former and feed commercialization opportunities to the latter.

There is no definitive model for an optimal innovation ecosystem, and it depends on both the level of development and the nature of broader political, economic and social systems. However, all countries that have successfully harnessed innovation for growth have had the full set of actors, organizations and enabling conditions. While organizations may be either public or private and vary greatly across countries, the enabling conditions—such as the policy and regulatory context, as well as market operations—are closely dependent on government action. Moreover, these enabling conditions are set almost entirely by national- or subnational-level governments, with the global innovation ecosystem forced to work across (or as a supplement to) them. For developing countries in particular, the robustness of its innovation ecosystem determines its "absorptive" capacity—its ability to adopt, adapt and successfully implement innovation.[4]

For the purpose of this paper, we posit that a robust global innovation ecosystem and supporting international cooperation must improve the effectiveness of national systems and tackle innovations that require supranational coordination. The fact that innovation ecosystems have formed and functioned predominantly at a national or subnational level, with enormous differences in their size and nature, raises a number of salient points for a potential international cooperation. First, this cooperation must work effectively across countries with large gaps in their ability to create, access, adopt and disseminate innovation. Second, it must facilitate coordinated decision-making and a collaborative work environment in setting transnational enabling conditions. Finally, it must do this while accommodating differences in national-level organizational structures and enabling conditions.

WHAT IS DIFFERENT ABOUT INNOVATION FOR GREEN GROWTH?

Innovation for green growth is similar to innovation more broadly, but does have a few distinguishing characteristics owing to the nature of the green growth perspective. The term green growth has several definitions. Similar to sustainable development, it advocates a concept that optimizes economic growth while incorporating the full economic and noneconomic value of natural resources and advancing social equity and inclusion.[5] However, the selection of the word "growth" instead of "development" is intentional—the approach is grounded in a belief that continued economic expansion is compatible—if not dependent on—improving resource efficiency and socially equity.

We also consider green growth to take a more process-focused and transformative approach than that of sustainable development. Sustainable development tends to focus on defining the set of social and environmental objectives within which economic development should occur, and implicitly or explicitly prescribes a set of end-state natural resource constraints on economic activities. Green growth, in contrast, focuses on creating pathways for sustainable economic growth with system conditions that integrate economic, social and environmental values, with a particular focus on their interdependency.[6]

Relative to innovation more generically, innovation for green growth has a few distinct characteristics worth highlighting:

- The benefits or avoided costs exceed economic value as reflected in market prices, and include various "externalities" beyond the typical spillover effects associated with innovation. Moreover, the benefits in the long term are more important than is reflected in typical private sector discount rates or even social discount rates since they include the avoidance of catastrophic events difficult to incorporate into near-term decisions.

- The benefits of innovation involve a high degree of global interdependency, so that local actions have relatively larger benefits to third parties including those quite far removed from the creation and implementation of the innovation.
- Individual innovations need to more often conform to a radical transformation of the current growth pathway, requiring a relatively high degree of coordination and mutual dependency, and significant "all or nothing" tipping points. At the same time, radical green growth innovations often delivers an "old fashioned" service (e.g. electricity or personal transport) reducing the typical market catalyst for such radical innovation (e.g. a critical mass of early adopters).

Overall, these distinctions mean that innovation for green growth requires:

i. A more central role for the public sector in creating adequate enabling conditions *with innovation in mind*, especially the supply-demand mechanisms that communicate economic and social value (e.g. carbon pricing).

ii. A significant divergence from the traditional "catch-up" model for innovation common to many developing countries, with earlier and more intense involvement in innovation, occurring simultaneously with first deployment.

iii. A more prominent role for global mechanisms that facilitate global value optimization, and improve coordination across countries in facilitating large transformational shifts in growth pathways—hence strengthening the case for an international architecture with a particular focus on green growth.

GREEN GROWTH AND REACHING THE BASE OF THE PYRAMID

A particular challenge will be ensuring that green growth innovation reaches markets at the Base of Pyramid (BOP), enabling broader and low-cost access to energy services and water, for example. A focus on these markets would need to expand the range of opportunities available to countries that have been slower to expand their formal innovation activity.[7] The collective purchasing power of the BOP (defined as living on less than $9 per day) amounts to roughly $5 trillion, equivalent to the combined GDPs of Australia, Spain, Mexico and South Korea. Yet, formal innovation by both public and private organizations, including that conducted in the BOP and that focused on the BOP, has been very low.[8]

There are several reasons for such limited formal innovation for the BOP. First, their own public funding is scarce and often focused on short-term priorities. Second, global public innovation funding does not tend to cross national boundaries, and tends to be focused on the domestic needs of the financing countries, or on large and accessible foreign markets. Third, official development assistance (ODA) tends to target direct poverty alleviation, often with an immediate focus, and gives very little emphasis to innovation support. Fourth, the risk-adjusted financial rate of return in these markets is relatively high, and available innovation capacity low, so large corporations neither focus their innovation activity in these markets nor for them. Finally, smaller, domestic companies in these markets have less access to long-term financing, weaker balance sheets, etc. and hence little ability to invest in innovation. The combination of these factors means it is highly unlikely for BOP countries to reach an accelerated path of green growth innovation without a high degree of international collaboration and support.

Some evidence points to the fact that BOP countries could be fertile ground for expanded innovation support. Significant informal innovation activity exists, primarily around business models and institutional arrangements that increasingly encourage entrepre-

neurship. Moreover, revenue generating business models to benefit the BOP are increasingly being examined in development and business circles, and some companies with strong social equity and sustainability agendas have encouraged innovation for BOP markets. Nevertheless, realizing accelerated green growth innovation is going to necessitate much faster capacity building in the BOP economies, and policy and financial incentives that address the key barriers and incentivize green innovation both in and for the BOP.

BARRIERS AND TOOLS

Barriers to innovation exist at all stages of the technology chain and influence absorptive capacity in developing countries in different ways. Figure 2 below provides an overview of the types of barriers preventing successful innovation from taking root in developing countries, and corresponding opportunities to overcome them.

A number of policy instruments have been developed to address these barriers and to help build the innovation

FIGURE 2: BARRIERS TO GREEN GROWTH INNOVATION IN DEVELOPING COUNTRIES

Barriers	Opportunities
Conflicting policy instruments that fail to adequately internalize sustainability benefits.	Establish green growth policies that send consistent market and nonmarket signals to incentivize transformative development pathways that integrate long term economic, environmental and social benefits.
Lack of infrastructure, or prevailing infrastructure for fossil fuel use.	Public investment and policy incentives that overcome prevailing conditions and create an enabling environment for business to pursue green growth opportunities.
High risk associated with infant markets and policy uncertainty.	Financing tools appropriate to new risk categories, and capable of instilling confidence in long-term policy stability.
High up-front capital costs associated with initial transition.	Financing tools to mobilize large institutional investor funds, and development and mobilization of local capital markets.
Fear of losing intellectual property rights and lack of enforcement mechanisms.	Improved international trade agreements, and the development of more “open innovation” mechanisms (e.g. World Intellectual Property Organization, patent purchase pools).
Lack of frontier and adaptive innovation capacity.	Creation of new research capacity and facilities, and improved ability to leverage knowledge networks and benefit from international partnerships.
Lack of innovation commercialization capacity.	Entrepreneurship and commercialization support to promote new product development and diffusion for local markets while reducing deployment costs.
Environmentally harmful subsidies (e.g. fossil fuel and water) or lack of pricing of externalities (e.g. carbon).	International and national policy incentives.
Tariff and nontariff barriers to trade in environmental goods and services.	Improved international trade agreements, and more dynamic competition and technological diffusion.
Reliance on external financial support in least developed countries (LDCs) leading to short term policymaking.	Creation of national science, technology and innovation policies in LDCs to drive long-term innovation commitments based on longer term growth, productivity and sustainability objectives.

Source: UNESCO (2010), EBRD (2011), Ockwell et al. (2010).

ecosystem at both the national and international level (Figure 3). Many of these come from non-green growth sectors, but also apply to green growth innovation. Summarized in the table below and in Appendix 1, these instruments form broadly three categories: demand "pull" policies, incentive "push" policies (financial or otherwise), and collaborative structures. In addition to these specific policy instruments, government also helps create critical ecosystem conditions through education and training support, protections for intellectual property, and legal conditions that facilitate commercial risk-taking.

Each incentive instrument has both benefits and risks that must be carefully considered through robust policy frameworks and implementing agencies. Employing demand "pull" policies may have benefits including reducing commercial uncertainty; educating consumers to make better purchasing decisions; conferring a price premium to leading producers; and encouraging producers to be transparent about impacts. At the same time, they risk setting performance standards too high or too low; have difficulty ensuring deployment to target recipients; may not stimulate R&D that is far from market; and may not have an effect in a market without many substitutes.

Incentive "push" policies are the most common innovation policy set and can be financial or otherwise. Benefits of these instruments include promotion of early stage innovation; faster and higher quality development through competition; participation from both large and small organizations; and direct and high impact stimulus for socially beneficial innovation. Risks associated with incentive systems includes performance requirements set too low; lack of market signals (i.e. picking losers); crowding out of private sector innovation funding, and the inability to influence commercialization phases of innovation.

Collaborative structures have the added benefit of encouraging knowledge sharing; minimizing individual transaction costs through pooled resources and R&D; helping arrive at a technology solution more quickly; promoting intellectual property rights (IPR) sharing; reducing deployment costs; and helping technologies reach target populations in multiple countries. Risks include discour-

FIGURE 3: POLICY INCENTIVE INSTRUMENTS, DESCRIPTIONS AND EXAMPLES OF REAL WORLD INITIATIVES

Instrument	Description	Example
Demand "Pull" Policies		
Pricing or Taxing Carbon	Setting a price on the market externality, commonly greenhouse gas emissions.	European Emissions Trading System
Advanced Market Commitment	A binding contract that guarantees the purchase of a technology that meets certain performance requirements.	GAVI Alliance Pneumococcal Vaccine
Open Trade Policies	Policies that promote the unrestricted flow of environmental goods and services across borders.	Asia-Pacific Economic Cooperation
Product Labels	Certifications for product and services meeting certain social and environmental standards.	Fair Trade Certified Label
Procurement or Manufacturer Standard	A standard to purchase or manufacture appliances meeting certain environmental or social standards.	U.S. EnergyStar appliance standards

FIGURE 3: POLICY INCENTIVE INSTRUMENTS, DESCRIPTIONS AND EXAMPLES OF REAL WORLD INITIATIVES CONTINUED

Incentive "Push" Policies– Financial or otherwise		
Compulsory License Agreement	A legal permission to manufacture a technology without the consent of the patent owner.	Various provisions of Trade-Related Aspects of Intellectual Property Rights (TRIPS)
Pay-for-Performance Reward	A financial incentive disbursed upon achievement of a desired outcome.	Brazilian Development Bank (BNDES) Amazon Fund
Public Ranking	A ranking of organizations, countries, or municipalities based on socially responsible behavior.	Yale Environmental Performance Index
Research Grant	Funding to undertake a certain activity, sometimes awarded on a merit basis as agreed by a committee of experts.	U.S. National Science Foundation research grants
"Sticky" City Policy	Policies to encourage talented individuals and successful organizations to remain in developing countries/cities.	New Partnership for Africa's Development
Equity, Loan or Loan Guarantee	Quasi-commercial funding for innovative business activities that would otherwise be unable to garner commercial funding.	Government cleantech venture and seed funding
Tax Credit	Tax reductions granted to entities that undertake desirable activities.	Small business tax credits

Collaborative Structures		
Applied Research Network	A network of researchers that conduct collaborative research on applied topics.	The Consultative Group on International Agricultural Research (CGIAR)
Start-up or Innovator Network	A network of innovators or "start-ups" that promotes ideas sharing and facilitates access to markets and investors.	Center for Innovation, Entrepreneurship and Technology (CIETEC)
Patent Commons	A place to access patent resources that are made available to members or the public at large.	World Business Council for Sustainable Development (WBCSD) Eco Patent Commons
Patent Pool	A consortium of companies agreeing to cross license patents related to a particular technology.	GlaxoSmithKline (GSK) Patent Pool for Neglected Tropical Diseases
Technology Transfer Program	Programs that facilitate the transfer of technological know how and devices across borders.	United Nations Framework Convention on Climate Change (UNFCCC) Technology Mechanism

Source: Adapted from Appendix 1

aging partners from seeking collaboration opportunities with nonmember institutions; and excluding innovation from smaller innovators who either lack the capacity to participate owing to high transaction costs or fear losing IPR to larger, better funded partners.

Perhaps the most striking insight from a review of innovation policy tools is the dearth of information about what works, and the difficulty measuring and evaluating policy outcomes. Nevertheless, experience over the last few decades provides a number of broad principles about "best practice" innovation support that will need to be incorporated into any new mechanisms for international innovation support and collaboration:

- **Suitable to high-risk activities,** including tolerance for high rates of failure, which are often a sign that policy is well targeted, and very low transaction costs that are in line with small-scale and uncertain return to recipients.
- **Strategic but not prescriptive,** setting clear and broad target outcomes (e.g. decarbonization of energy supply) while remaining open to multiple, competitive and often unexpected solutions.
- **Joined-up across the innovation chain,** encouraging feedback from end-markets to new developments and vice versa, often linked to deployment and involving strong private sector participation.
- **Embedded with innovation ecosystem,** both in terms of developing local ecosystem capacity when required, and in terms of targeting support that is appropriate to existing local capacity.

III. TRENDS IN GREEN GROWTH INNOVATION IN EMERGING AND LEAST DEVELOPED COUNTRIES

GREEN GROWTH INNOVATION activity remains heavily concentrated in developed countries (including newly developed countries like South Korea) with a dominant position in terms of overall innovation activity, and frontier innovation in particular. Nevertheless, the balance is clearly shifting as an emerging tier of large new innovator countries—including China, India and Brazil, for example—has begun to close this gap, and transform the global innovation ecosystem. At the same time, a new gap has opened where the least developed countries (LDCs) represent a smaller and smaller share of global innovation activity despite impressive economic growth.

Developments of national and international innovation ecosystems tell a similar, if more nuanced story. The new tier of emerging innovators have developed deep capabilities and supportive enabling conditions, and achieved a strong innovation supply chain as a complement to their growing economic activity and industrial development. This investment in the national ecosystem largely preceded the boom in innovation activity, and has now facilitated increasing integration into global innovation supply chains. Least developed countries are in an earlier stage, although there may be significant informal innovation, especially in operational systems, business models and organizational structures, which is harder to gauge. Behind these overarching patterns exists a wide diversity of national conditions, providing a variety of options to building a robust innovation ecosystem.

Despite these generally auspicious trends, the overall amount of innovation activity across both developed and developing countries remains low relative to that required for a timely green growth transformation. The gaps are particularly large in areas requiring systemic innovation that fundamentally alters existing infrastructure development pathways.

RESEARCH, DEVELOPMENT AND DEMONSTRATION SPENDING TRENDS

Innovation spending provides the most direct measure of innovation activity. Although data across countries are often imperfectly comparable or incomplete, estimated R&D spending reached $1.3 trillion in 2011 (measured in purchasing power parity terms) across all sectors, green growth and otherwise. This is a 17 percent increase since 2008. Spending was led by the United States (32 percent), China (13 percent), and Japan (11 percent)[9]. In total, developed countries[10] plus China account for about 90 percent of total R&D spending, reaching almost 97 percent if you add India, Russia and Brazil.

There is a tier of emerging country innovators, led by the BRIC (Brazil, Russia, India and China) countries in terms of absolute spent and proportion of GDP spent, followed by countries like South Africa, Hungary and Turkey in terms of the proportion of GDP spent. In recent years, these countries have doubled (or more) the proportion of GDP spent on R&D, even as GDP has risen sharply. China is again the most outstanding case going from 0.6 percent of GDP in 1995 to 1.6 percent in 2011. If it follows the trend of the United States in the 1950s, or South Korea in the 1980s and 1990s, it will join the tier of the developed countries within 10 to 15 years.

Nevertheless, the gap remains very large. No developing country apart from China is spending more than 1.2 percent of GDP on R&D, and the least developed countries spend well below 0.5 percent. This compares with 2.5 percent on average for developed countries, and more than 3 percent for leading countries like Denmark, Sweden, Israel, South Korea and Japan. Those countries not among the emerging country innovators would face at least 30 years of "catch up" if recent history is a good indicator.

With regard to green growth R&D spending, no broad "green" R&D spending indicator exists but one proxy is renewable energy R&D. The developed countries again appear to dominate with about 75 percent of total renewable energy R&D in 2011. Here too, China stands out among developing countries with about 19 percent of world total—together with Brazil and India accounting for over 80 percent of developing country R&D.[11] Evidence related to broader green growth technologies (including both renewable energy, carbon capture and storage, low carbon services, and energy efficiency related technologies) confirms these trends, as does data on spending for demonstration projects. Adding these to the picture increases the gap between developing and developed countries, and between emerging innovator countries and other developing countries.[12] Finally, it is worth noting that case study-based research also confirms that environmental sustainability has been an active area in emerging innovator countries.[13]

PATENT TRENDS

Another way to measure national green growth innovation activity and ecosystem capacity (especially for frontier innovation) is through patent data. While not a perfect proxy, as intellectual property (IP) protection is less of an incentive in developing countries than in developed countries, these patent trends are valuable indicators of innovation activity.

A recent World Bank study of OECD data on U.S.-issued patents found that high-income countries dominate the issued patent landscape.[14] Whereas high-income countries produced more than 6,000 U.S.-issued green technology patents[15] (GHG-reducing technologies only) between 2006–2010, excluding China, developing and emerging countries combined produced fewer than several hundred.[16] Even more telling, the gap between developed and developing country U.S.-issued patents has widened since 1996, suggesting that recent convergence in GDP has not closed the gap in frontier innovation activity.

Developing country green growth innovation is led by East Asia-Pacific countries, with a total of 49 green patents from 2006–2010, followed by Southeast Asia (17 patents) and Europe and Central Asia (13 patents). The data also suggest that some emerging economy technology innovators are beginning to distinguish themselves.[17] China is the most prominent, but other emerging economies also stand out including India, Brazil, Russia, Argentina, Malaysia, Mexico, Hungary and South Africa. In all, these countries account for 80 percent of green patent grants to all developing countries.

Patterns of technology patenting in terms of sector and scale also vary between countries at different income levels. Across climate change mitigation technologies, between 2001 and 2010 the greatest share of patents in high-income countries was issued to advanced vehicle and waste-to-energy technologies. In developing countries they were issued to wind and solar technologies, the third and fourth most popular issued patent categories in high-income countries. This gives some indication that developing countries are focusing innovation in areas where they have emerged as major producers. Nevertheless, some emerging economies are beginning to pursue patents in technology sectors in which there had been no patent activity before 2001, such as advanced vehicles, biomass and lower-carbon cement.[18] This indicates a potential trend in which the new tier of emerging economy innovators are leading with innova-

tion in order to compete in sectors where they have no historical precedent as producers.

Finally, the patent data provides some insight into the direction of technology transfer, and the dynamics of the global innovation ecosystem across developed and developing countries. While the direction of technology transfer remains heavily North-South, emerging economies are investing more heavily in technology R&D. This is particularly true for innovations developed and first adopted in China and India before moving to Northern and other Southern markets. While one might expect such trends to emerge eventually in U.S. patent issuances, evidence for any such trends has hitherto been absent: U.S. patent issuances to teams of South-South collaborators across all types of technology stands at a mere 0.3 percent.[19] This suggests a few possibilities. First, South-South innovative collaboration may remain almost nonexistent. Second, these collaborators may not see value in U.S. patents, or find the cost too high to apply for U.S. patents given they are looking to serve local and not global markets. Third, the possibility remains that much of the innovation happening in the Southern context is not what might be called "formal" innovation, but rather is informal innovation that is not well-measured by a narrow indicator like patent activity. Such activity in the innovation ecosystem would be useful to understand better, but the challenge remains on how to measure such informal innovations in practice.

Overall—while there are some promising trends among one tier of emerging economies, the national patent trends still point to low overall green growth innovation, at least with regards to frontier innovation related to goods and services. Moreover, the extent of green growth innovation activity in least developed countries and their participation in the global innovation ecosystem remains particularly low. This also reinforces our earlier evidence that developing country innovation capacity for green growth innovation remains relatively small.

Overall, the available evidence on research, development, demonstration and deployment activity suggests that gaps between developing and developed countries remain large across both frontier and adaptive innovation, and that only a handful of countries (primarily China) may be on course to close these gaps in the foreseeable future.

RESEARCH AND DEVELOPMENT SECTOR TRENDS

Since a critical role for international innovation cooperation might be to increase funding and improve the effectiveness of funding by reducing duplication in areas with large and urgent innovation requirements, it is important to understand where the largest gaps exist in current green growth innovation activities. Although definitions are imperfect and some technologies serve multiple purposes (e.g. general information and communications technology for smart grids), the evidence suggests that explicitly green growth related R&D spending is only a small fraction of the global total (probably less than 5 percent).[20] Moreover, even in the OECD countries, which have relatively high green growth R&D spending, estimates suggest current R&D spending on clean energy technologies is far less than what might be required per annum to achieve a low-carbon transition quickly and at the lowest cost.[21]

Interestingly, the gaps in OECD countries are relatively small for solar and wind technologies for which markets have already developed, and for which significant infrastructure changes (e.g. to the electricity grid) are not required, at least initially. On the other hand, green growth technologies requiring significant system transformation, like carbon capture and storage (CCS), advanced vehicles and smart grids seem to face large gaps in required versus available financing. At the same time, large gaps exist in energy efficiency innovation, which tends to involve many technologies interacting in often complex systems. This tendency is amplified

in developing countries. While we saw that developing countries account for about 25 percent of R&D spending in renewable energy, their share of R&D spending for a broader set of green growth technologies (including smart grid, energy storage, energy efficiency and advanced transportation) is only about 10 percent, with China accounting for about 80 percent of this.[22]

RESEARCHER HEADCOUNT TRENDS

The number and trends of active researchers in each country provide a measure of innovation capacity, especially with regards to R&D. In 2007, developing countries had 37 percent of the world's science researchers, up from 30 percent in 2002.[23] They also had about 40 percent of science and engineering doctoral students. The data on these trends are not comprehensive, but the largest growth appears to be among the group of emerging innovator countries, especially China.

At the same time, the OECD Math, Science & Technology Indicators database suggests that even the most advanced emerging economies still have fewer than two math and science researchers per 1,000 employees, with least developed economies much lower. By comparison, the five developed countries with the highest ratio, all of which are in Scandinavia, employ more than 10 math and science researchers per 1,000 employees.[24]

The most advanced emerging economies also have much lower ratios of private sector researchers to total employees than high-income countries.[25] This reinforces the evidence that frontier innovation capacity is low in some of the most advanced emerging economies, and suggests that the adaptive capacity of is also low, since private sector researchers tend to drive adaptive innovation with its greater focus on commercialization.

While data did not give proportions for researchers in green growth industries, these trends suggest that both publicly and privately funded research capacity still has a large scope for expansion in developing countries in order to close the gap with developed countries. Nevertheless, at least in some countries research capacity appears to be large relative to existing innovation activity. This represents a positive trend in terms of ecosystem maturity, and suggests that at least some countries are underutilizing their potential capacity.

INSTITUTIONAL STRUCTURES AND ENABLING CONDITIONS FOR INNOVATION

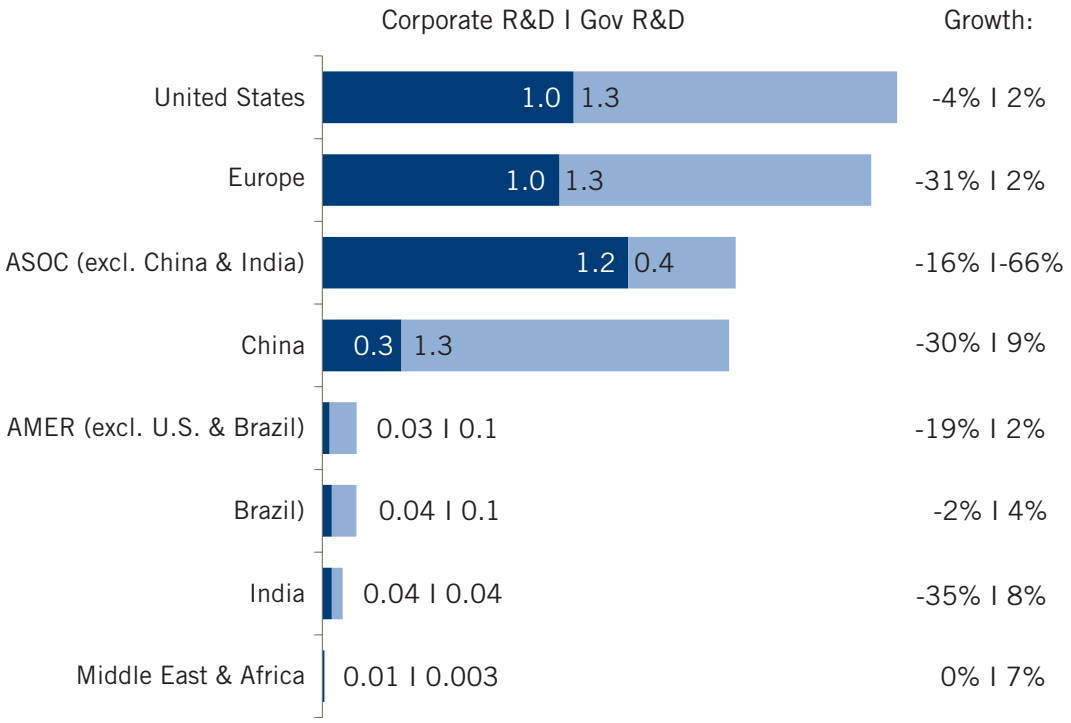
While national and subnational innovation ecosystems share a common set of actors and organizations (research institutions, entrepreneurs/firms, financial institutions, etc.), there remain significant differences in their relative size and role, and in the robustness of the ecosystem in which they act. In understanding the potential role, operation and governance of an international architecture for innovation, there are a few key features worth highlighting.

First, the roles of the government, private sector and "third sector" (e.g. universities or research institutes) in funding and performing innovation differ across countries. Moreover, unlike innovation activity levels, these differences do not clearly track overall levels of development.

While the government is usually a large source of funding, its relative size fluctuates greatly between countries and sectors. For example, if we look at renewable energy RD&D, government spending has generally accounted for more than half of the total between 2005 and 2011, but country-level variation is high (Figure 4).[26,27]

The governance of public sector funding also varies greatly—in some cases, national science and technology ministries/agencies dominate public funding, in other cases funding may be split between sector

FIGURE 4: R&D INVESTMENTS BY RENEWABLE ENERGY COUNTRY



Source: BNEF, IEA, IMF, various government agencies as cited in BNEF and UNEP, 2012.

focused ministries (e.g. Ministry of Industry) in combination with education focused ministries.

Similarly, the nature of private sector financing can vary greatly. While in most countries private sector funding for innovation is predominately self-financed up until deployment, in some countries relatively large and independent venture finance institutions have emerged, while in others quasi-public financial institutions often provide concessionary lending terms that take into account the added innovation risk.

Countries also vary widely in terms of the role of different institutions in performing innovation. The extent of national laboratory systems, the size and independence of universities, and the role of large versus small companies all vary greatly across, and even within, countries. For example, the role of higher education institutions tends to be much greater in Europe than it is in Japan, South Korea or China. And even within Europe, the role of such institutions in the UK is larger than in other countries.

A second key difference across countries is the robustness of broader enabling policies for innovation, including education and training, IPR protections, and supply-demand mechanisms that communicate economic and social value. Previous sections docu-

mented the large differences in education and training support in scientific disciplines, particularly the gap between developed countries and a new tier of emerging innovator markets on the one side, and least developed countries on the other. Similar gaps exist when it comes to the creation of market demand conditions, where the adequacy and extent of "pull" mechanisms (e.g. efficiency standards, labeling programs, feed-in-tariffs, etc.) vary greatly across countries, mostly in line with the deployment trends analyzed below.

Unlike these two enabling policies, differences in IPR protections can vary in ways that do not closely match development levels. IPR policies are sometimes characterized by what can be seen as arbitrary and inconsistent application. Between countries, and even between sectors in a specific country, the IPR conditions include: aggressive industrial policies, in some cases to "steal" foreign technologies and in others to protect against them; conscientious neglect that allows the local private sector to do whatever it likes or can get away with; and relative enforcement, sometimes in collaboration with other countries. Unfortunately, this too can leave BOP countries underserved—on the one hand unable to effectively adopt leading technologies without the full support of IPR suppliers, and on the other hand, caught without that support owing to conflicts between those same suppliers' larger emerging markets.

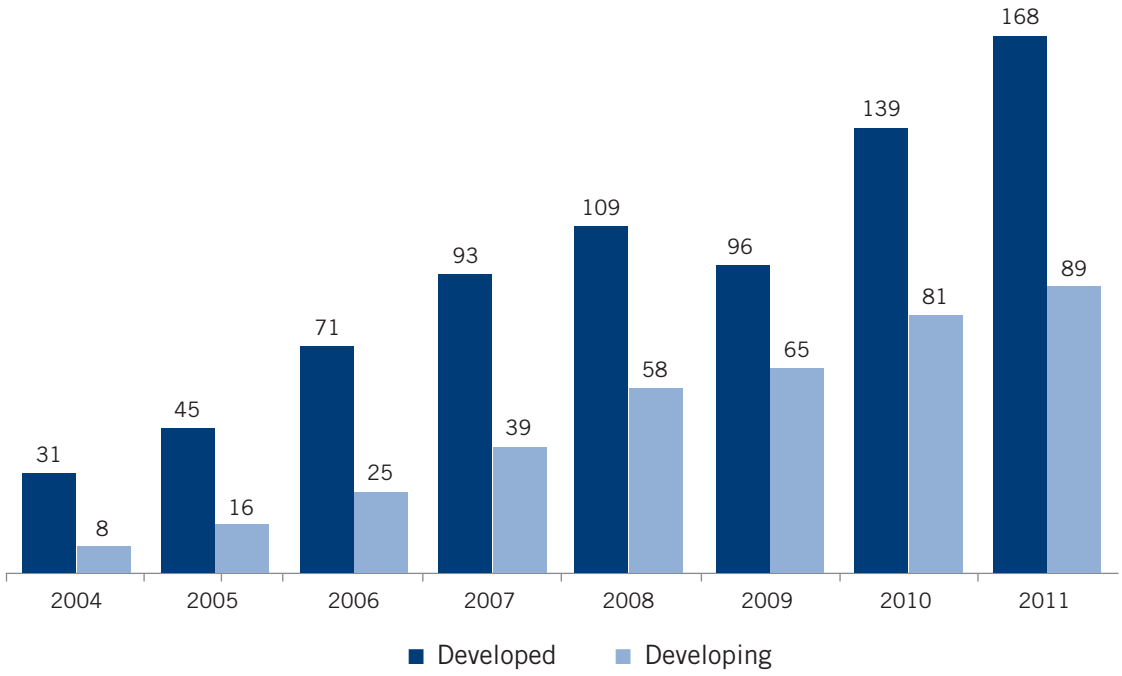
A third key difference worth highlighting is the degree to which national innovation ecosystems are integrated into global innovation supply chains. Recent work has highlighted the globalization of innovation supply chains over the last few years. The best available evidence suggests that this has been a gradual process, with some acceleration since the middle of the last decade led by large multinational companies. Data on U.S. multinationals' R&D abroad shows an increase from about 12.5 percent in 1998 to 15.7 percent in 2008. There are also strong signs of this growth accelerating since the mid-2000s, with overseas R&D employment of U.S. multinationals increasing from 16 percent to 27 percent between 2004 and 2009. Nevertheless, other developed countries still constituted the destination for over 85 percent of U.S. overseas R&D in 2008, although overseas R&D spending to developing countries has generally increased two to three times faster than to developed countries.

Besides being a growing destination for R&D outsourcing, more detailed case study-based analyses highlight increasing numbers of local innovation champions and trends toward "reverse innovation," where innovation originating in developing countries is transferred to developed countries.[28] Again, we see integration into global innovation systems driven primarily by the emerging innovator countries like China and India, and to some extent Brazil, Mexico and Malaysia. Evidence for the least developed countries indicates few and relatively isolated success stories. In general, the pattern of development indicates that integration into the global innovation system has lagged behind macro-level economic and innovation capacity growth, suggesting it is a result of local development, rather than a leading cause.

DEPLOYMENT INVESTMENT TRENDS

Deployment trends provide a final indicator of green growth innovation activity, especially in terms of adaptive innovation. Here the relative increase among developing countries is most pronounced. From 2005 to 2011, the share of total renewable energy investment in developing countries has increased from 26 percent to 35 percent, although this share has stabilized since 2009. In absolute terms, the developing world has increased its investment more

FIGURE 5: FINANCIAL NEW INVESTMENT, DEVELOPED VS. DEVELOPING COUNTRIES



Source: BNEF and UNEP, 2012

than tenfold, as compared to less than fivefold for the developed world (See Figure 5).[29]

Although developing countries at all income levels have shown significant growth, larger emerging countries are again dominant. For example, China, India and Brazil accounted for about 75 percent of the investment in renewable energy among developing countries over the period from 2004 to 2011, a number very similar to what we saw for R&D spending. This is in spite of accounting for only 57 percent of GDP over this period. Hence, these emerging innovators are both growing faster, and expanding their renewable energy activity at a relatively quicker pace (roughly two to four times faster).[30] Despite strong growth rates, the least developed countries absolute levels of investment in renewable energy remains very low.

Moreover, the prominent role of emerging innovator countries is even more pronounced for levels of energy production and investment. For example, developed countries have led by a far greater extent in distributed energy investment over the last few years with roughly tens times the investment of developing countries versus roughly equal investment levels in utility-scale renewables.[31] Yet while accounting for a very small proportion of distributed solar deployment, China led with over 50 percent of worldwide production, demonstrating how an emerging innovator country can leverage its innovation capabilities to serve international markets even in the absence of domestic activity.

IV. INTERNATIONAL COOPERATION: OVERVIEW OF EXISTING INITIATIVES

THROUGH A COMBINATION of desk research and interviews, we initially identified more than 300 international initiatives with a stated mission to advance at least one sector of green growth. While this can only be a partial list, we believe we have identified the most significant initiatives with respect to operating models utilized, services rendered, geographies of focus, and technology stages affected. Overall, approximately half of the initiatives we surveyed can be considered as only indirectly targeting the research, development, deployment and diffusion of technology. These are organizations without missions or objectives to influence the technology development cycle, although they are working towards the goal of accelerating green growth.

We then narrowed the list to some 163 international initiatives that most directly support green growth innovation (Appendix Table 3). In order to be included on this list, initiatives had to meet the following three requirements:

- International—having at least two organizations from different countries providing operational support or being run by one organization with operations in at least two countries.
- Noncommercial entity including nongovernmental organizations (NGO), government, or intergovernmental organization (IGO), or public-private partnership.
- Either conduct technology research, development, deployment, or diffusion or have as one of its stated objectives to support technology innovation.

To limit the scope of the analysis to areas that were relatively less understood, we excluded initiatives that focused solely on supporting large-scale investment programs, while recognizing that the deployment stage they support is an important part of the innovation agenda. These large funds, like the Global Environment Facility, the Climate Investment Funds and the newly created Green Climate Fund, as well as flows from the multilateral development banks, national development banks and bilateral investment funds are of course part of the larger international architecture, and the recommendations will make appropriate links to them in the latter sections of this report.

Most organizations engaged in these initiatives were either governmental (including intergovernmental) or nongovernmental organizations. While private sector participation was widespread, there were few initiatives structured as full public-private partnerships.[32] Most of these organizations perform technology research, or they coordinate the RD&D activities of their members. Most also provide information sharing, including everything from report publication to the maintenance of public databases to conference convening, often in combination with providing technology research. Emphasis is most often on the earlier stages of the innovation spectrum, with fewer organizations focused on demonstration and initial deployment. Notably, direct financing and business support services were relatively rare, provided in less than a quarter of the initiatives.

Over 80 percent of these 163 initiatives were split roughly between a global or developing country focus, with the latter generally covering large, geographically cohesive regions. Sub-Saharan Africa was the most commonly covered region owing to ODA related support. While initiatives focused on developed countries were fewer in number, their relative weight in funding is much larger, especially if one excludes Africa. Most

initiatives coalesce around a specific sector, with energy, including energy efficiency, and agriculture, due to the share of African initiatives, by far the largest areas of focus, followed by water (also often tied to agriculture), and then forestry, biodiversity and transport.

The rest of this section provides a detailed discussion of the initiatives by services provided, organization type, geographies of focus, sectors of coverage, and technology areas targeted.

ORGANIZATION TYPES AND IPR FRAMEWORKS

The analysis shows that of the roughly 163 green growth innovation initiatives surveyed, over half were governed by government entities (including IGOs), while about 40 percent were governed by NGOs. Most of the governmental initiatives were multilateral partnerships with a significant bias toward collaboration among advanced economies, and to some extent the tier of emerging innovators. The most common types of multilateral arrangements on the list are a joint R&D agreement between International Energy Agency (IEA) member countries with 42 current technology implementation agreements, and the suite of arrangements under the European Commission, with €20–30 billion a year in funding. A notable arrangement of multilateral cooperation is the Consultative Group for International Research (CGIAR). There also exist a number of large initiatives involved a single developed country (e.g. Switzerland, U.S. and Japan) engaging with multiple developing countries. Such arrangements are the primary vehicle for government-led collaboration between developed countries and least developed countries. In contrast, most of the NGOs listed are North-South partnerships. Many of these efforts are far smaller than the large government-led initiatives, with a few notable exceptions, such as the Bill and Melinda Gates Foundation. At the same time, NGOs receive a large part of their funding from governments.

The role of the private sector is somewhat more complicated. On the one hand, we have already seen that a certain degree of purely private sector international "collaboration" is occurring through the globalization of innovation supply chains.[33] In addition, most of the largest international innovation initiatives involve private sector participation (albeit predominately from developed countries), most often as partners in conducting public- or NGO-funded innovation, but increasingly also as active participants in the process of defining innovation priorities. Yet on the other hand, cross border public-private partnerships for green growth are uncommon. Domestic partnerships for green growth are more common though still few in number. The United Nations Development Program (UNDP) Special Unit for South-South Collaboration has identified 28 public-private partnerships for sustainable development, of which 23 are in developing countries.[34] Almost all of these initiatives are partnerships among organizations in the same country and thus were not candidates for evaluation for this research project. The few that were international partnerships did not have a stated mission to stimulate innovation. Overall, our research yielded only a handful of international public-private partnerships that directly support RDD&D, and most of these were fairly recent initiatives (e.g. the U.S. Water Partnership, Sustainable Energy for All, and EU Joint Technology Initiatives), and private sector commitments are often modest.

There seem to be several reasons for the relative rarity of both North-South private sector collaboration and public-private partnerships in international innovation initiatives. First, some partnerships founder because of a real or perceived lack of equivalent protection and enforcement of IP rights across countries, and the desire by private sector entities to protect IP for self-commercialization. Alternatively, many developing countries have put in place Trade-Related Aspects of Intellectual Property Rights (TRIPS)-compatible

IP systems; in these cases, competitive factors and the availability of public funds to support North-South collaboration could be at least as important as IP issues. Most international innovation programs with significant private sector participation have either relied on flexible approaches essentially determined by partners at the project level, or in some cases on broader frameworks that exclude nonmembers, and usually require complex arrangements. Such arrangements can work, but they generally rely on a common overarching IPR regime, and are often limited to North-North consortia. Another reason is the ease of private sector partnering with domestic agencies and universities due to proximity and institutional familiarity. When international innovation cooperation is desired, most parties (research institutes, companies or governments) often prefer bilateral agreements to multilateral arrangements in order to maintain quality standards, better control budgets, and build one's own competencies and brand in a competitive environment. Finally, there remains a larger systemic divide: while many developed countries have created an open and competitive system for funding green growth innovation and a consortium of companies has gradually developed to take advantage of this, many developing countries take a more integrated industrial policy approach. Despite the attempts of the IEA and recent public-private partnership initiatives, in the absence of significant amounts of funding for North-South collaboration, there is little incentive to overcome these barriers.

SERVICES PROVIDED

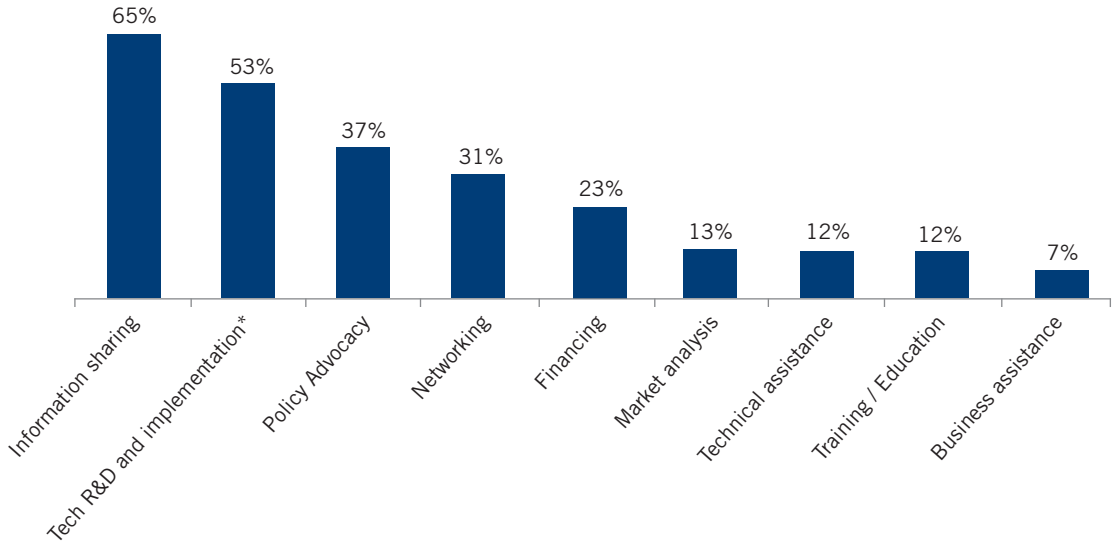
Organizations that work in the green growth space provide a host of services, from direct technology research and development to technical assistance, training and business advisory services. Of the initiatives on the list, the majority provide technology R&D and information sharing services (Figure 6). A "Technology R&D" service is one that either involves the performance of direct R&D activities or the coordination of client/member R&D on the basis of financing provided by a third party.

The most popular service is information sharing (including free report publication, public online database maintenance, policy brief preparation and conference convening), provided in many cases as a required complementary activity to technology R&D services. Despite the popularity of information sharing systems, international organizations continue to call for the development of new information sharing platforms. This could suggest that there remains a need for more such initiatives, that existing initiatives are failing to provide the information required to accelerate innovation, or they are failing to effectively disseminate this information to all potential beneficiaries. Or, it could represent an institutional default position of sorts—a fairly low-cost, low-risk framework that allows stakeholders to initiate activities.

The second most common technology R&D services are usually provided in one of two models. In some cases they are linked to the provision of financing—about one-fifth of the organizations surveyed provide financing services, including research grants, fellowship/scholarships, and debt and equity placements, almost always in conjunction with technology R&D services. In others, they create a collaborative platform, with some strategic guidance, but with funding provided by members. In either case, they can be multilateral (e.g. the funded Joint Technology Initiatives and the unfunded IEA Implementing Agreements[35]), unilateral (e.g. funded Science and Technology Research Partnership for Sustainable Development SATREPS), or nongovernmental (e.g. the funded CGIAR and the unfunded Global Bioenergy Partnership). Note that organizations whose only service provided is financing were not included in this analysis.

In distant third, fourth and fifth places in popularity are policy advocacy, networking and financing. Just under 40 percent of organizations on the list provide policy advo-

FIGURE 6: SHARE OF INITIATIVES BY SERVICE PERFORMED**



Source: Brookings, 2012

*Note: *Tech R&D, Tech Implementation: These organizations either perform technology R&D or implementation (deployment) themselves, or they coordinate their clients' / members' activities in these areas.*

*Note: **Percentages total more than 100 percent as many initiatives perform multiple services.*

cacy services and a similar number provided networking services, which includes activities from conference hosting to virtual connections with foreign researchers to making the connections for entrepreneurs to receive seed capital from investors. Least common service areas were market analysis, nonbusiness related technical assistance, training and education, and business assistance—each performed by fewer than 15 percent of all organizations.

One example of an initiative providing business advisory services is the Infodev-supported Climate Innovation Center Network. Following an assessment of climate innovation needs in developing countries, Infodev, an international partnership housed at the World Bank, has created business plans for seven of these centers to be opened in emerging and developing countries. The centers will provide soft loans, business training, technical assistance, networking and market information while working with host country governments to develop policies that support clean technology absorption. Another example is the Global Change System for Analysis, Research, and Training (START) that builds capacity among researchers and institutions in Africa and Asia through grants, fellowships and training programs.

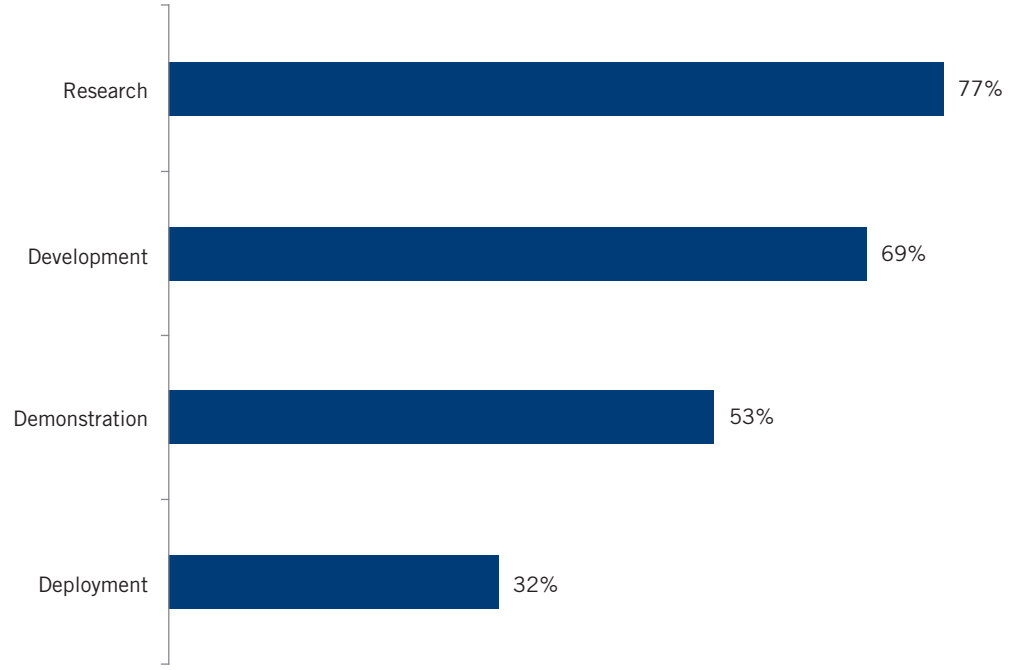
Despite such notable exceptions, the overall dearth of technical and business advisory services point to the lack of capacity building support that might be most beneficial to BOP countries, which haven't yet developed the ecosystem required to take advantage of technology R&D, information sharing, networking and financing opportunities. This relative dearth may also mean that green growth research and development efforts are not strongly enough linked to businesses and deployment projects that actually implement such innovations.

INNOVATION PHASES TARGETED

Initiatives surveyed target all four phases of the innovation cycle, although there is a large skew toward the earlier stages (Figure 7). More than three-quarters target the research phase, and about two-thirds target both research and development. Initiatives that perform research, development and/or demonstration but stop short of deployment also tend to be those focused on technology R&D and information sharing services, with less emphasis on services related to capacity building. For these initiatives, the driving goal is R&D excellence in terms of frontier innovation, rather than excellence in terms of the adaptive innovation perhaps better catered to the needs and capacities in developing countries.

Fewer initiatives studied targeted the demonstration and deployment phases alone. Later phase projects require larger funding commitments and greater coordination of large national investment policies. They require extensive private sector involvement, and a relatively more complex assessment of the optimal public-private leverage ratios. Because of scope limitations in the study design, the instruments that support the large scale demonstration and deployment phase, such as the large investment funding vehicles (like the Global Environment Facility or the Climate Investment Funds, Green Climate Fund or other multilateral and bilateral investment flows), were not studied in detail. However, almost all of this funding has gone to support deployment of proven technologies with relatively little focus on the riskier earlier stages of the RDD&D continuum. One exception is the program to fund a major scale-up of concentrated solar power in North Africa under the Climate Investment Funds' Clean Technology Fund. Further research to understand the extent to which multilateral and other international coop-

FIGURE 7: SHARE OF INITIATIVES BY PHASE TARGETED*



Source: Brookings, 2012

*Note: * Percentages total more than 100 percent as many initiatives address multiple sectors*

eration on the investment side is accelerating take-up of new technologies is needed.

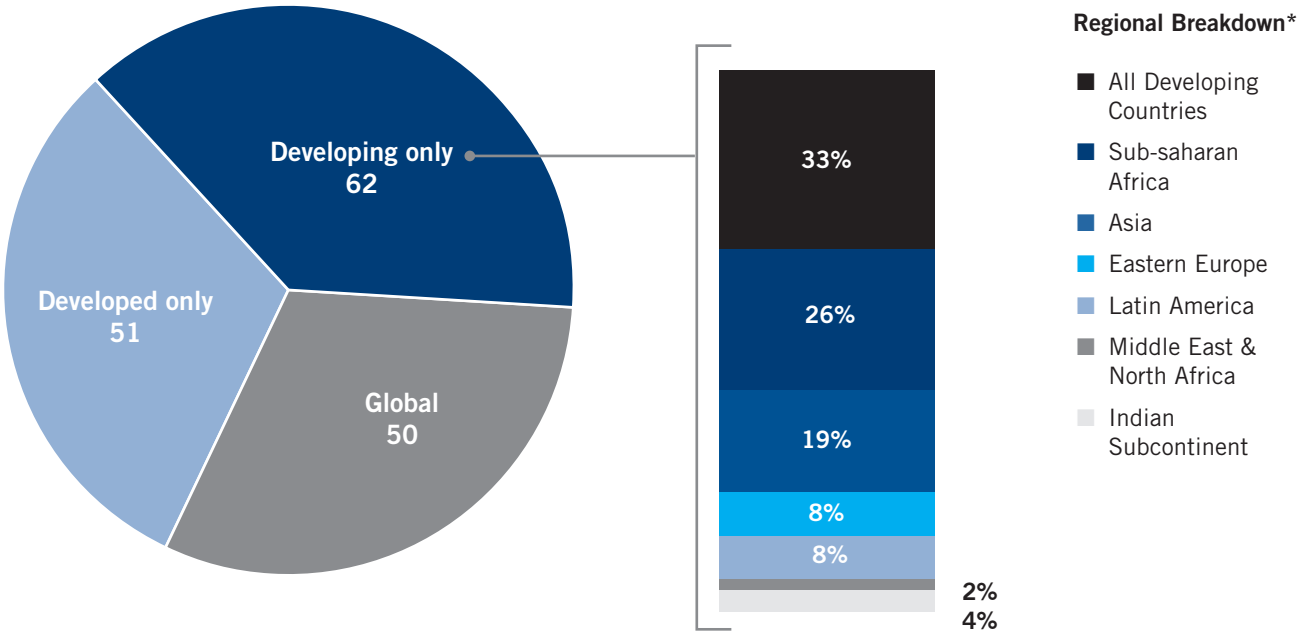
Some initiatives have put emphasis on linking their work across the innovation cycles. Two notable examples are the IEA, which works to draw in the private sector and demand-led considerations into its frontier-focused innovation activities, and a number of health and agriculture focused efforts like the Consultative Group on International Agricultural Research, which are heavily driven by poverty alleviation goals, and put more emphasis on local needs and adaptive innovation.

REGIONAL DISTRIBUTION

The geographic distribution of international green growth innovation initiatives shows a relatively large emphasis on developing countries. Close to 40 percent of the initiatives surveyed focus exclusively on green growth innovation for developing countries. Of these, over one-third are programs with no specific regional focus, followed by sub-Saharan Africa (26 percent), East and South Asia (19 percent), Eastern Europe (8 percent) and Latin America (8 percent)[36] (Figure 8). Least common recipients are countries in Middle East/North Africa and the Indian subcontinent. It is important to note that the geographical distribution of international initiatives is quite different from the distribution of green growth innovation activities (as detailed in the previous section), which tends to be much lower in sub-Saharan Africa.

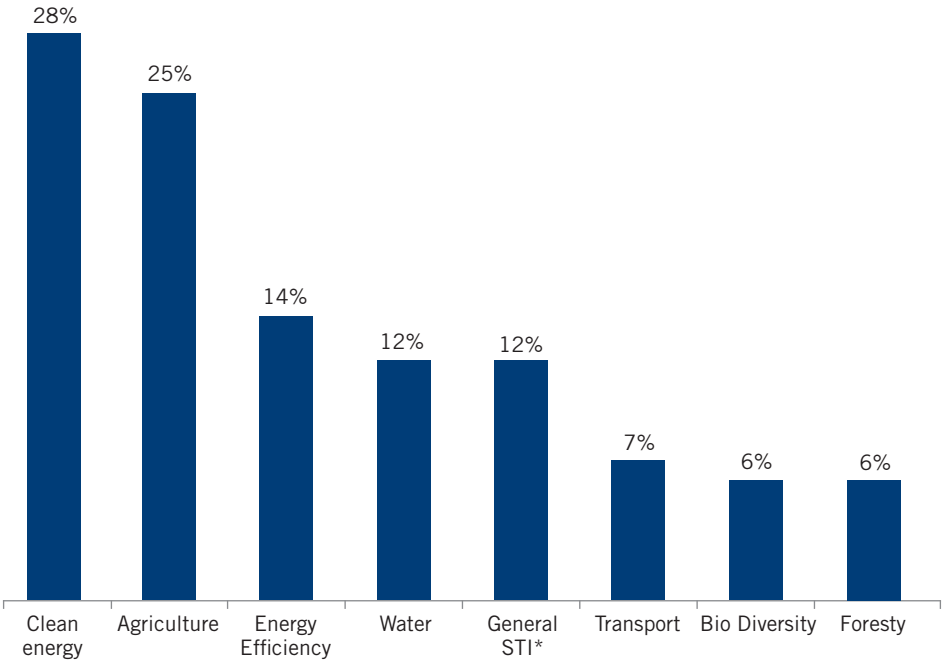
Many initiatives look to reduce tons of emissions and therefore focus on countries and regions like China where there are strong opportunities. Others have a

FIGURE 8: GEOGRAPHIC BREAKDOWN OF TARGET RECIPIENTS



Source: Brookings, 2012
*Notes: * Initiatives targeting developing countries only*

FIGURE 9: SHARE OF INITIATIVES BY SECTOR**



Source: Brookings, 2012

*Note: *General STI = Science, technology, and innovation programs, inclusive of environmental issues*

*Note: **Percentages total more than 100% as many initiatives address multiple sectors*

poverty alleviation mission and ODA orientation, with a focus on least developed countries like many in Africa. The relative lack of focus in Latin America may be explained by the combination of low-emissions intensity and middle-income status nations, and notable pre-existing Latin American programs like the Inter-American Institute for Global Change Research—an IGO that supports the exchange of scientific information across borders by funding collaborative research, running technical trainings, and hosting workshops for information exchange. Yet middle income countries with high green growth improvement potential like non-EU-affiliated Eastern Europe and Central Asia and South Asia may be falling between the cracks.

Perhaps even more importantly, while less than one-third of the initiatives on the list target developed countries, these are among the most generously funded, thanks largely to the EU programs. Moreover, developed countries largely dominate many of the global initiatives most notably the IEA Implementing Agreements. Hence while the relative number of organizations focused on the developing world points in the right direction, the relative funding tells a less optimistic story.

SECTORS TARGETED

For the vast majority of initiatives, a sector rather than regional focus drives their work. About 80 percent of the initiatives were focused on a specific sector, while only about 40 percent were focused on a specific region with over half of these EU focused. The energy sector claims the greatest share at 28 percent, followed by agriculture at 25 percent, and energy efficiency at 14 per-

cent (Figure 9). This finding is not surprising considering the tangible profit opportunity in renewable energy and energy efficiency in developed countries, and the economic reliance of most developing country economies on agriculture. Energy and agricultural initiatives are also those that tend to most target all four phases of the innovation cycle. We expect that the popularity of these two sectors is consistent with global investment trends in clean technology. As noted above, renewable energy appears to have a relatively high proportion of innovation activity.

The international organizations sponsoring renewable energy are also among the largest, including the International Energy Agency, the Clean Energy Ministerial of the Major Economies Forum and the suite of EU initiatives. All have a relatively large focus on developed countries and frontier innovation. Moreover, the growing participation of the private sector is dominated by industry from developed countries, in line with the national sources of funding. Notable exceptions exist, and large efforts are being made to expand developing country involvement. For example, the IEA's Energy Technology Data Exchange and Network of Expertise in Energy Technologies have an explicit mandate extending to developing countries. Also, the Clean Energy Ministerial manages the Renewables and Efficiency Deployment Initiative (Climate REDI), an $85 million set of three projects to spur the adoption of energy efficient technologies in developed and emerging economies. Nevertheless, the bulk of international green growth innovation initiatives are focused on energy, developed countries, and frontier research and development.

In this context, it is also interesting to note the relative lack of initiatives in green transport, carbon capture and storage, and electricity networks and storage. All together, such initiatives account for less than 15 percent of total funding (with transport alone at 7 percent), and tend to be focused almost exclusively on developed countries. This suggests a particular gap in innovation areas requiring coordinated, systematic change and large demonstration phases (e.g. smart grids). While there are a number of bilateral initiatives, international activities in this arena tend to be in the area of knowledge sharing similar to the Clean Energy Ministerial. Moreover, new financing mechanisms like the Clean Technology Fund and UK assistance under the Capital Markets Climate Initiative are looking to attract private sector support to fund major breakthrough investments. These are focused on the deployment end of the innovation chain and focus on meeting country-driven needs. They are less focused on high-impact, systematic technology transformation, or the international collaboration to create synergies across such efforts.

Those initiatives that support alternative energy innovation for the least developed countries are heavily focused on the deployment of renewable energy, energy efficiency, and, to some degree, distributed technologies. Among the larger programs is the Lighting Africa Initiative. The Lighting Africa Initiative is a joint International Finance Corporation/ World Bank project that works to stimulate deployment of off-grid lighting to rural African communities by providing business advisory services to private firms. Another example of this type of program is the newly created Sustainable Energy For All initiative, which aims to mobilize actors across a broad spectrum for urgent action, on a global level and in developing countries. It has three sustainable energy objectives to achieve by 2030: ensuring universal access to modern energy services; doubling the rate of improvement in energy efficiency; and doubling the share of renewable energy in the global energy mix. Although focused on the deployment stage, these programs aim to spur the initial adoption of new technologies with significant adaptive innovation and the potential to create demand for frontier innovation focused on least developed countries.

The agricultural sector provides the best model of numerous and, in some cases, well-funded initiatives with a focus on developing countries across the innovation cycle and with strong North-South and South-South collaboration. In large part, this is due the benefits of agricultural innovation in poverty alleviation and health, which get more attention in a system still driven by "aid" organizations. The major international organization financing and coordinating innovation is the Consultative Group on International Agricultural Research. CGIAR is a 50-year-old research alliance with an annual budget of more than $500 million and a network of 15 research centers. The centers conduct R&D on staple crops and ecosystems for human sustainability and have come to be viewed as best-in-class examples of international applied research centers. Another major agricultural program is the Alliance for a Green Revolution Africa (AGRA). With a budget of nearly $400 million, AGRA provides technical training, coordinates seed and soil R&D, supports graduate students in agroscience, and expands market opportunities for rural farmers.

Like agriculture, initiatives focused on water tend to target the later innovation phases, are run by NGOs, are part of larger R&D initiatives like the CGIAR,[37] or are embedded in international organizations (like the Water Supply and Sanitation Program housed at the World Bank, which focuses on policy innovation) or linked to health-focused programs. The relative lack of international water initiatives focusing on innovation is curious given the threats to water availability and quality posed by population growth, climate change and chemical contamination by anthropogenic substances.

The least common sectors for international green growth initiatives are forestry[38] and biodiversity. This may have to do with the fact that innovation is perceived as less important to conservation than policy instruments to discourage ecosystem damage and deforestation. To some extent forestry conservation initiatives are often also biodiversity initiatives, and thus biodiversity protection is assumed by organizations conducting forestry or agroforestry work without it being stated explicitly in a mission statement. Of the few technology-oriented biodiversity initiatives that exist, most fall under the umbrella of agriculture (e.g. gene banks) or involve the use of information communication technology to catalogue and monitor species, population and ecosystem diversity.

V. OPPORTUNITIES TO BUILD A STRONG INNOVATION ECOSYSTEM

THE BROAD GOAL of supporting innovation pathways for the emerging and developing worlds is widely shared and discussed in climate change and development circles. In fact, as we have seen, scores of international initiatives to support green growth innovation activities exist with services ranging from financing and policy advocacy to on-the-ground technical assistance. However, there has been extensive documentation that policies to date have been unable to mobilize the implementation capacity, degree of innovation, and pace of investment needed to ensure developing countries achieve a green growth trajectory consistent with goals such as zero net deforestation, a net increase in attractive employment opportunities through sustainable enterprises, and reduced risk of cataclysmic climate change (e.g. a 450 ppm pathway) by 2020.[39] Green growth innovation requires a particularly strong mix of concerted public policies, accelerated broad-based diffusion that goes beyond typical "catch up," and global coordination. An incremental shift of long-standing innovation support mechanisms is unlikely to suffice.

GAP ANALYSIS

The previous sections provided an overview of global trends in innovation activity and a survey of existing international initiatives. This overview, in the context of our broader literature review, suggests the following gaps in international support for green growth in developing countries.

- *Insufficient green growth innovation activity in developing countries and a lack of significant international initiatives to remedy this* (with the partial exception of agriculture). This is particularly true for the LDCs, but holds even for the emerging innovator countries especially in frontier innovation.
- *Insufficient innovation capacity in LDC countries, and scarcity of capacity building in international initiatives.* Evidence has shown that capacity building has been instrumental in facilitating the scale up of adaptive innovation, emerging frontier innovation, and take-up of new technologies in emerging innovator countries.
- *Insufficient international collaboration in the form of North-South and South-South partnerships.* This is true of both the emerging innovators and BOP, but the latter are more deeply shut out owing to their underlying lack of capacity and lower level of integration into global supply chains.
- *Insufficient integration from innovation to implementation, and a lack of international mechanisms that might support this (such as financing for IP-sharing or de-risking entrepreneurial investments).* This is particularly relevant for small and medium enterprises (SMEs), who more often lack the required resources.
- *Insufficient global spending on green growth innovation, with some indication that the biggest gap is in innovation areas requiring coordinated, systematic change and large demonstration phases (e.g. smart grids).* New financing mechanisms (e.g. the Clean Technology Fund, and possible the Green Technology Fund) are more focused on deployment rather than high-impact innovation breakthroughs.
- Finally, it is critical to note that there remain *deep gaps in our understanding of what forms of innovation support are most effective*. This includes critical

questions about the participation of the private sector (e.g. what if any models of public-private partnerships might work), and the relative value of services which are less widespread (e.g. business assistance services).

While the wide array of existing institutional arrangements and their expansion should play a key role in overcoming these gaps, new pathways for international collaboration could confer several important benefits. First and foremost, they could facilitate the full involvement of a new tier of country financiers and technical assistance providers. There is a class of countries with both the ability to contribute more significantly to global green growth in developing countries and a strategic interest in doing so, as their GDP levels and technological development over the past decade have revealed. Second, we believe the scale and scope of the challenge is so great that it requires a significant realignment of support mechanisms. Existing initiatives to support green growth in developing countries are radically inadequate to the green growth innovation challenges faced by those countries, and funding pools for innovation in LDCs are virtually nonexistent.[40] Such a change in funding levels is unlikely without new arrangements for pooled financing, interinstitutional coordination, reduced transaction costs, etc. The next section provides a more detailed exploration of these significant new requirements.

OPPORTUNITIES: DESIGN CRITERIA

A new international approach to supporting green growth innovation will itself require innovative institutional design, and innovation-driven implementation. While we propose a set of broad new institutional arrangements, we hope for this to be the starting point of ongoing debate and refinement. As such, it is equally important to lay out the key conditions we believe any successful new architecture will need to meet.

It goes without saying that a new architecture needs to be complementary to existing and emerging international initiatives to stimulate clean technology RDD&D such as the UNFCCC Technology Mechanism, CGIAR, Infodev Business Incubator Centers, Clean Energy Ministerial and the Green Climate Fund. New arrangements will need to understand not only the gaps in services provided by these organizations, but also the programs that have been most successful so they can be replicated in other countries and to other sectors. These should build on, and where applicable, scale up the most promising of the many policy and IP tools that are being tested (Appendix Table 1).

Based on our analyses for this paper, we posit the following design criteria for new international partnerships:

- **Focus on building innovation capacity in LDCs.** The least developed countries will need to undergo an unprecedented transition in innovation activity to meet the demands of a green growth transformation. History shows that this will require major advances in absorptive innovation capacity and the broader enabling conditions for a robust innovation ecosystem, including improved science, technology and innovation (STI) education, policies of human capital mobility and in-country retention, and public support mechanisms to stimulate "discovery" at all levels of innovation (from SMEs to research laboratories). In parallel, international innovation funding must explicitly focus on the innovation challenges of LDCs, and leverage the STI capacity of more developed countries to this purpose. It will be essential to fully engage these countries in the design, strategy setting and operation of new collaboration to ensure sufficient buy-in and impact. Finally, this must all be underlined by support for robust national innovation policies, well aligned with broader green growth development goals.
- **Support innovation across the technology value chain through to end-markets.** Markets for green products and services are

highly dependent on policy support and emerging international agreements. As such, they lack much of the "pull" on innovation inherent in other markets, which we saw to be so critical in the recent take-off of innovation in emerging innovator countries. As such, green growth research and development must be more strongly linked through to demonstration and deployment. This could include linking innovation to carbon markets, deployment support, consumer marketing or public procurement. It could also include logistical support for supply chain development and security, business advisory services and various mechanisms to support green growth entrepreneurship.

- **Be flexible and take risks to respond to unknown future market needs.** Large new initiatives across a wide range of unfamiliar geographies requires a flexibility and comfort with risk that is largely at odds with today's initiatives, which are most often based on either an ODA-model or a fairly tight-knit arrangement between government funders and national beneficiaries. Meeting the challenge will require a mandate to "go big," while acknowledging the uncertain nature of innovation, and retaining the flexibility to adapt to changing conditions. For instance, rather than an organization to finance and administer a fixed type of challenge program, one might create an architecture with a broad mandate to select from among existing challenge programs, advanced market commitments, patent pools and whatever unforeseen innovation mechanisms might arise. This will require a degree of core support and independence unusual in international initiatives.
- **Facilitate the sharing of intellectual property.** The need to break down continued barriers to IPR sharing and open R&D collaboration will go well beyond the project-specific efforts indicative of current initiatives. A new architecture needs to make this a central plank of global collaboration, serving as an instrument to resolve these issues at a systematic level (e.g. as a knowledge and device broker or technology transfer facilitator).
- **Include financial innovation to de-risk private investment at early venture stages.** To supplement government support and create commercial focus, it will be important to offer innovative financial products that leverage public investments and incorporate private capital early on. De-risking instruments include first loss funds, sovereign risk insurance, collateralized loans with flexible interest rates depending on project outcomes, etc. While de-risking funds exist that support this objective (e.g. the Clean Technology Fund and likely the new Green Climate Fund), the focus has been on deployment of proven technologies and adapting these to local institutional and policy settings.
- **Attract a new tier of developing countries.** There is a class of countries with both the ability to contribute more significantly to global green growth in developing countries and a strategic interest in doing so, as their GDP levels and technological development over the past decade have revealed. These countries include China, Brazil, the United Arab Emirates and Qatar, among others. A new international architecture should break from the current Northern dominated arrangements and provide these countries with the opportunity to shape and own the large expansion of international innovation support, and assume an active role in global environmental stewardship. Moreover, new instruments should aim to attract not just policymakers from these countries, but also private sector and nongovernment actors.
- **Encourage transparency and accountability.** While avoiding the rigidity of micromanagement, a significant scale-up of international innovation support would benefit from an overarching mechanism that measures and evaluates results over long timeframes. By maintaining a degree of independence from specific

implementing initiatives, a new international function could offer incentives for performance in the form of reputation enhancement, financial awards, implementation assistance and a forum for showcasing achievement.

- **Tackle the challenges of green growth innovation that require global coordination.** International coordination comes at a cost and national innovation systems, as well as competition across them, have proven capable of achieving significant and efficient innovation. A new international architecture must focus on challenges for which there are clear benefits to collaboration apart from international transfers to LDCs. Evidence of underspending on RD&D in areas of large, systematic transformation (e.g. low carbon transport, smart grids and CCS) suggest potential areas of focus.

VI. TOWARD A NEW INTERNATIONAL PARTNERSHIP

OUR RESEARCH SUGGESTS that four categories of programs offer the most likely value for a renewed international initiative to support green growth innovation:

- A program to catalyze capacity building to develop innovation ecosystems in least developed countries;
- Significantly scaled-up investment via competitive grants to fund R&D in least developed countries, which would build networks and capacity while yielding innovation results;
- Investment in networks of business incubators to spur entrepreneurship and link innovation to market demand and financing opportunities;
- Dedicated funds to de-risk entrepreneurial investments and stimulate the sharing of intellectual property.

These should be complemented by scaled-up funding to support public, private and public-private investments at scale for innovations that require a complex suite of policy support and coordination, such as smart grids or transformational urban infrastructure. Further analysis is needed to assess whether existing institutions and programs can accomplish this, or whether a new funding mechanism is needed.

Finally, these four areas would be more powerful if deployed simultaneously because they address complementary elements of the innovation ecosystem.

BUILDING CAPACITY FOR INNOVATION: INNOVATION CAPACITY CATALYSTS

Over the last few decades, we have seen various countries emerge as both innovation and growth leaders, including South Korea in the 1980s and 1990s, and more recently China and other emerging innovator countries. These transitions were led by strong national capacity building, taking one to two generations (or 20–40 years) to reach levels comparable to developing countries. Achieving the same success in today's least developed countries will require a similar focus on capacity building.

Dedicated funding for cultivating innovation capacity and catalyzing robust innovation ecosystems in the least developed countries could serve to accelerate this critical transition. Innovation capacity catalyst funds could provide a toolkit of policy planning support for "innovation ecosystem readiness"—this would ensure LDCs had a solid basis for their innovation ecosystem development priorities. These could then provide funding support to the fulfillment of these plans.

We propose mechanisms be developed that would be flexible to the needs and demands of different countries and open to all national or multinational proposals (whether from public, private or nongovernmental entities) aimed at building the green growth innovation ecosystem. Innovation capacity catalyst funds could thus fund a wide variety of initiatives, including initial course development and faculty support, education scholarships, e-learning and knowledge network development, seed funding for technology innovation centers or other RD&D related institutions and infrastructure. They would encourage experimentation, facilitate South-South and North-South collaboration and knowledge sharing in capacity development, and aim to test and disseminate best practice. They would also closely link to the international initiatives to scale up R&D and transformative demonstration, providing the

necessary capacity for full LDC participation in these efforts, while at the same time using these efforts to reinforce capacity building activities. Some international funding pools already exist that might be directed toward innovation. In the near term, the most efficient way to establish funding would be to focus on these existing institutions and partnerships. New funds coming online, such as the Green Climate Fund, might also be structured to provide some support.

CULTIVATING TECHNICAL KNOWLEDGE: SCALING UP R&D THROUGH COMPETITIVE GRANTS

Fifty years ago, the CGIAR was created to invest in long-term research and development, and is credited with launching the green revolution in developing countries. At that time, because of the dearth of research institutions, the founders created dedicated research institutions and today some $500 million is channeled to the 15 CGIAR centers. The purpose of the CGIAR is to support breakthrough adapted research while building capacity, and is a good analogue to the green growth agenda that also calls for significantly stepped up R&D investment, especially in least developed countries. However, the setting today, with a wide number of networked actors, calls for a different form. Rather than following the institutional model of the CGIAR, which relies on channeling its funding to the CGIAR centers, we propose instead to build a more open competitive framework that would make funding available either in parallel, or through national foundations. This would rely on creating a pool of dedicated, long-term funding for R&D, which could fund promising researchers and institutions via competitive processes.

One organizational option would be to create a network of regional science foundations in developing regions to encourage greater South-South collaboration in all types of innovation. Another option might be global science foundations around key areas (e.g. energy, transport, etc.). The foundations could be intergovernmental agencies charged with setting regional science priorities including but not limited to green growth, and deploying funds provided by both member governments and international aid donors to meet these priorities. Funding would be distributed in the forms of R&D grants, fellowships, and cooperative/extension programs with in-region and out-of-region nonprofits and firms working in priority areas as determined by the foundation. Such institutions would also support international knowledge networks for researchers, entrepreneurs and other practitioners, including regular meetings and conferences, as well as virtual knowledge sharing platforms. Practices could usefully build on examples from the U.S. National Science Foundation, the European Science Foundation, and the Third World Academy of Sciences. Grant criteria could encourage capacity building and collaboration by requiring researchers to partner with peers at other leading research institutions.

CATALYZING ENTREPRENEURSHIP: INNOVATION INCUBATORS

Organizations that support entrepreneurs in the private sector to bridge R&D and commercialization have shown to be a dynamic force in supporting aspiring entrepreneurs. To support innovation deployment and enterprise development, a proven model of support is a set of national (or subnational) business incubators. An internationally sponsored network of business incubators could provide a broad and flexible suite of services to in-country entrepreneurs and start-ups working in all green growth sectors. The incubators would also be responsible for identifying and conducting outreach to promising entrepreneurs and start-up companies, and defining commercial and noncommercial criteria for selection. The global network would select incubators to be funded (encouraging experimentation), support functions best developed at scale (e.g. noncommercial

evaluation methods), facilitate knowledge exchange (including information about their incubated companies), and identify and disseminate best practices.

The services they could provide include seed funding, business plan support, networking facilitation, access to finance (e.g. international venture capital), access to market research and to markets (e.g. corporate supply chains and public procurement), pitch training, finance training, office space, facilitation of technology transfer, and negotiation of IP licenses. With regard to the last point, the incubators could support and enhance the pipeline quality of existing green technology transfer mechanisms such as the UNFCCC Technology and Clean Development Mechanisms. They could also be designed to create clusters around large national universities or research institutes, and encourage a researcher-to-entrepreneur model. The success of innovation incubators depends on the existence of ambitious entrepreneurs and a good governance context. As such, initial stages of any program would ideally select the host countries carefully, mindful of these necessary conditions.

Models to build on include the Infodev Climate Innovation Centers, the Center for Innovation, Entrepreneurship and Technology (CIETEC) in Brazil, the Center for Innovation, Incubation and Entrepreneurship (CIIE) in India, and university technology transfer offices such as those at the Massachusetts Institute of Technology and Stanford University.

DE-RISKING FUNDS FOR INNOVATION INVESTMENT AND INTELLECTUAL PROPERTY SHARING

Large, dedicated funds to encourage private investment in developing country innovation projects and in local companies driving innovation will be important supplements to the large deployment funds expected over the coming decade. A risk capital fund would provide development-oriented financial instruments to investors and project developers for supporting companies (or consortia of companies) interested in accelerating the deployment of innovative technologies. Financial instruments include but are not limited to concessional loans, sovereign guaranteed loans, first loss funds, partial credit or risk guarantees, and equity or quasi-equity investments. Provision of such risk capital and other de-risking instruments would be most effectively utilized in combination with, or embedded in, a larger deployment fund such as the Green Climate Fund. These funds should be dedicated to support earlier stages of product development and demonstration, with the goal of fast-tracking deployment. They could take the form of venture capital type support, they could form a supplemental innovation fund alongside a larger deployment funding commitment, or they could work in combination with advanced market commitments.

The fund for IP sharing would provide financial support to both developers/owners of IP and buyers of IP. It would diffuse those technologies believed to have a large impact on green growth, with the aim of supporting developing countries in adopting leading edge technologies. Access to IP could go through nonprofit and social impact organizations that are able to distribute technologies to eligible beneficiaries. Products provided by the IP sharing fund could include but are not limited to: subsidies for temporary licensing agreements, financing for patent pools, and financing for implementation assistance to be provided along with patent information. Such funds could be managed by the Green Climate Fund's Private Sector Facility, a similar entity, or a new fund altogether. Examples of patent sharing programs include the Pool for Open Innovation against Neglected Tropical Diseases, the World Business Council for Sustainable Development EcoPatent Commons, and the WIPO re:Search Open Innovation Platform.

It is important to note that the de-risking fund/s would not be self-financing, and would expect to lose,

potentially significant amounts, of money on any single investment, and to gradually accumulate losses over time. By taking on risk to leverage private investors where they wouldn't invest otherwise, the public funds are increasing their own risk-return ratio to the point where they should lose money if they successfully fulfill their role.

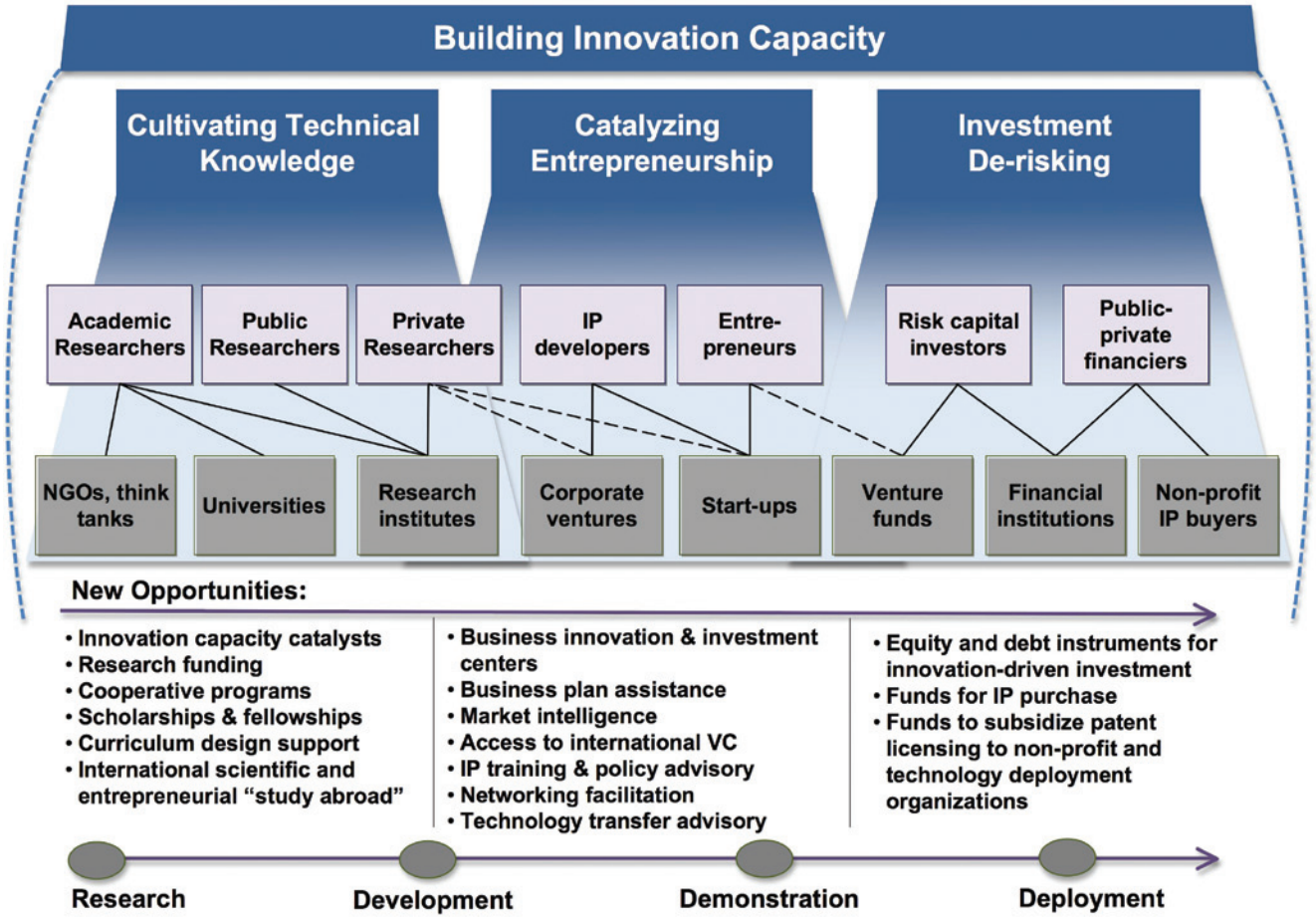
SYSTEM-LEVEL TRANSFORMATION: DEDICATED FUNDING FOR INVESTMENT

Although tremendous advances have been made in renewable energy innovation (across RDD&D) and in agricultural innovation, there remain large gaps in the demonstration and deployment in green growth areas requiring large system-level transformation. Even in developed OECD countries, efforts in these areas are underfunded, and in least developed countries there is virtually no progress being made. To tackle such innovation challenges, especially in countries where meaningful demonstrations are beyond national funding capacity, there is a need for significant funding to promote system-level transformations. The list of potential investments includes smart grids, low carbon transportation networks, integrated urban master planning, large scale water management and CCS. The focus needs to be on creating a portfolio of projects that more systematically tackle key uncertainties and innovation challenges, with knowledge sharing across the portfolio allowing learning-by-doing benefits beyond those of isolated projects. While the knowledge sharing facilitated by these funds should involve countries at all levels of development (linking into demonstration projects globally), direct project funding would be focused on demonstration projects in developing countries, especially the LDCs. This would encourage adaptive innovation to prove and improve the value proposition of a green growth trajectory, and would facilitate the buildup of local absorptive capacity with the ultimate aim of allowing developing countries to "leap frog" their infrastructure development more directly to green growth solutions.

One can posit that this transformation goal is already embedded in a number of active programs—like the Global Environment Facility and the Climate Investment Funds, which look to support transformative change, and the planned Green Climate Fund—and what is needed is sufficient funding to fulfill their goals. It is clear that the developing world is looking for the kind of scale up of funding that would be needed to help them transform to low-carbon and climate resilient futures. At the same time, because of the country-driven nature of these funds, the bias appears to be for deployment of proven technologies and the sector coverage is not strategic at a global level. As such there may well be gaps in support for critical technologies (e.g. CCS is not a technology currently supported). Further research to examine the emerging portfolios of these as well as other bilateral funds is needed to understand the actual gaps. To the extent that the objectives and processes of these funds are not meeting the innovation agenda, it may be useful to consider dedicated technology transformation funds, either as part of the existing suite of funds or as a new dedicated fund that targets specific green technology alternatives at scale. Specific Technology Development Facility demonstration projects could be structured as PPPs, in a fashion similar to that of Europe's Joint Technology Initiatives. Research on this alternative can be included in the future research agenda.

Figure 10 depicts new collaborative mechanisms that combine the first four initiatives described above. This new collaboration is rooted in support for capacity building for innovation. It would further strengthen capacity while providing impact through new R&D by supporting scaled-up knowledge creation via a competitive grant program. Entrepreneurship support would broaden the coverage of national business incubators, working through universities, research

FIGURE 10: A NEW INTERNATIONAL APPROACH TO SUPPORT GREEN GROWTH IN DEVELOPING COUNTRIES



Source: Brookings, 2012

institutes, nonprofit organizations and start-ups to reach individual researchers, students, and budding entrepreneurs. This would in turn be complemented by a set of funds to deploy risk capital for the diffusion of technologies that have been proven at the demonstration stage. As a network these collaborative mechanisms would provide full financial, technical and business support to researchers, developers, business people and financiers along the RDD&D continuum.

Of course, the launch of new international arrangements with such a broad mandate runs the risk of creating unnecessary bureaucracy and slowing progress if not properly designed and executed. Building on existing institutions and bilateral arrangements by creating a consortium of actors with a coordinating mechanism could ensure low transaction costs while streamlining access to international finance, and consolidating brokerage and intermediary services.

VII. CONCLUSION

THE CHALLENGES OF the 21st century require all countries to imagine and implement new approaches toward enhancing their own—and global—economic prosperity. Embracing new pathways that are more environmentally sustainable and socially equitable need not divert resources from economic productivity, but rather can serve to fuel the engine of economic growth.

This path of green growth presents an opportunity to allow many existing industries to realize resource-efficient profitability while encouraging new industries, economic diversification and broader economic opportunities. Central to this green growth strategy is the development and diffusion of innovation at an unprecedented pace, and hence the implementation of systematic programming to support innovation in developing countries.

Seeding green innovation ecosystems across the world's regional and economic contexts will require intentional deployment of national policies and international partnerships. National policy is a key contextual driver of any innovation ecosystem, and we encourage extending the existing research and implementation in this area. Yet we have shown that many challenges will not be met by a purely national approach, and this study has focused on opportunities for international organizations and regional partnerships to contribute to this agenda.

While we have provided a blueprint for international approaches, additional investigation into some specific areas of implementation might help increase the impact and success of new initiatives. We therefore suggest the following areas as priorities for further assessment.

Research to support the next steps needed to develop these recommendations includes:

- Deeper assessment through case studies of the various support mechanisms that have been proposed for scaling up, so that the best features can be built into the design, while also better understanding what features are not working and what still needs to be tested.
- Defining options for and assessing possible organizational and governance structures for the recommended new international collaboration areas.
- Identifying ways in which international innovation support can interact with national level systems to promote optimal pathways toward robust national ecosystems.
- Evaluating options to support transformative investments, either through existing mechanisms or through a dedicated Transformation Fund.
- Assessing systems of private sector-driven innovation in new development contexts (including the globalization of innovation supply chains) to identify the best approaches to additional public support.

Further research is also needed in a number of broad areas:

- Identifying examples of successful national innovation ecosystem development to determine the various available pathways and key success factors.
- Identifying areas that are best enhanced through changes in national policies, and defining pragmatic policy pathways for achieving these policies.
- Identifying differences in the need for innovation support across countries, and across different development contexts and technology phases.

- Examining the relationship of public sector support to private sector innovation for the BOP, with a particular focus on informal innovation.
- Examining IP and trade policies supporting clean technology innovation in developing countries at different stages of development.

Green technologies have the potential to transform how the world's people secure energy, clean water, food and more. If centered on establishing robust and diverse innovation ecosystems, this transformation can, moreover, contribute to domestic and global economic growth. Innovation is only one component of the green technology transition, and more effective deployment of existing technologies is also of great importance. For example, the knowledge to do large scale water management exists already, as does the knowledge for smart grids, low carbon transportation networks, integrated urban master planning and CCS. For such technologies, the need is for greater incentives to implement larger scale deployment. Currently, green technologies face challenges that even regular technologies don't face—such as the lack of pricing for externalities in the market, and a global interdependency that raises the stakes but complicates market development. International partnerships can help fill the gaps that currently exist in fostering strong innovation ecosystems and increase innovation outputs. They can cultivate science, technology and innovation capacity, foster relevant R&D and entrepreneurial initiatives, and increase financing for IP diffusion and innovation-driven investment. With appropriate domestic and international policies to enhance the global context for innovation, the green growth transformation can be an opportunity for all.

APPENDIX TABLE 1

POLICY AND INTELLECTUAL PROPERTY INSTRUMENTS TO SUPPORT INNOVATION

Instrument	Description	Example	Benefits	Risks
Advanced Market Commitment	A binding contract that guarantees the purchase of a technology that meets certain performance requirements.	GAVI Alliance Pneumococcal Vaccine	• Reduces commercialization uncertainty by creating "pull" mechanism • Encourages BOP-oriented R&D from developed countries and the private sector • Limited liability for funder. No purchase required if milestones not met • Addresses all stages of tech spectrum	• Has only yet been applied to health technologies • Performance requirements may be set too low or too high
Applied Research Network	A network of researchers that conduct collaborative research on applied topics.	CGIAR	• Encourages institutional collaboration and knowledge sharing • Minimizes individual transaction costs through pooled funding and R&D • May help arrive at a technological solution more quickly	• May discourage partners from seeking collaboration opportunities with nonmember institutions
Challenge/ Prize Program	A competition to produce a technology that meets certain performance requirements in exchange for a reward, usually monetary.	Ansari X Prize for Spacecraft	• Promotes early stage innovation • Competition mechanisms stimulates faster, higher-quality development • Large financial reward encourages participation from large organizations as well as individuals, small organizations • Can require donation of financial reward in exchange for monopoly marketing rights to keep prices low	• Performance requirements may be set too low • If requiring surrender of monopoly marketing rights, may be insufficient incentive to develop best technology
Compulsory License Agreement	A legal permission to manufacture a technology without the consent of the patent owner.	Various provisions of TRIPS	• Helps ensure technology deployment • Can reduce deployment costs	• May not ensure deployment to target recipients
Open Trade Policies	Policies that promote the unrestricted flow of goods and services across borders.	North America Free Trade Agreement	• Can stimulate technology transfer	• May not have any impact on R&D or on BOP innovation
Product Labels	Certifications for product and services meeting certain social and environmental standards.	Fair Trade Certified label	• Educates consumers to make better purchasing decisions • Can confer a price premium to participating producers • Encourages producers to be transparent about impacts	• Unlikely to have an effect in a market without many substitutes • More appropriate for high-income consumers
Patent Commons	A place to access patent resources that are made available to members or the public at large.	WBCSD Eco Patent Commons	• Promotes sharing of patent information • May reduce deployment costs	• Deployment potential is reduced by lack of implementation "know how" to complement patent info • Discourages "blockbuster" patents to be donated because of the loss of monopoly marketing ability
Patent Pool	A consortium of companies agreeing to cross license patents related to a particular technology.	GSK Patent Pool for Neglected Tropical Diseases	• Reduces threat of infringement lawsuits • Reduces transaction costs (patent filing, manufacturing, marketing and distribution costs) to each partner • Increases profit generation potential of the combined partners, though not necessarily of each partner	• May reduce innovation from major players, for fear of having to profit share • May reduce innovation from potential smaller competitors, for fear of having to compete with firms in patent pool

Instrument	Description	Example	Benefits	Risks
Pay-for-Performance Reward	A financial incentive disbursed upon achievement of a desired outcome.	BNDES Amazon Fund	• Eliminates risk of financial disbursement without achievement of goal	• Recipients may become dependent on funding and be unable to self-finance behavior change
Procurement or Manufacturer Standard	A standard to purchase or manufacture appliances meeting certain environmental or social standards.	U.S. EnergyStar appliance standards	• Educates consumers to make better purchasing decisions • Can confer a price premium to participating producers • Encourages producers to be transparent about impacts	• Unlikely to have an effect in a market without many substitutes • More appropriate for high-income consumers
Public Ranking	A ranking of organizations, countries, or municipalities based on socially responsible behavior.	Yale Environmental Performance Index	• Stimulates behavior change through competition • Stimulates international/ shareholder/ employee pressure for change through publicity	• Rankings are only as effective as their readership and the perceived influence of the publishing organization
Research Grant	A financial donation to undertake a certain activity.	U.S. National Science Foundation research grants	• Stimulates R&D for socially beneficial outcomes	• Does not ensure commercialization, as it only affects early tech stages
"Sticky" City Policy	Policies to encourage talented individuals and successful organizations to remain in-city.	New Partnership for Africa's Development	• Provides incentives for talented individuals to remain in their home countries • Reconnects with expatriates abroad to continue to serve national interests	• May not directly impact technology development
Subsidy	A sum of money granted by a public entity to reduce the price of a good/service or to undertake a particular activity that is regarded as too expensive or unattractive.	Chinese subsidized poverty loans	• Stimulates corporate investment in socially beneficial projects • May reduce prices of goods that can fulfill basic needs	• May not produce a commercially viable technology
Tax Credit	Tax reductions granted to entities that undertake desirable activities.	Small business tax credits	• Stimulates corporate investment in socially beneficial projects • May reduce prices of goods that can fulfill basic needs	• May not produce a commercially viable technology
Technology Transfer Program	Programs that facilitate the transfer of technological know how and devices across borders.	UNFCCC Technology Mechanism	• Helps technologies reach target populations in other countries • Reduces transaction costs of international market access	• May not stimulate R&D innovation

Source: Brookings, 2011

APPENDIX TABLE 2

DEVELOPING COUNTRY GREEN GROWTH GAPS AND OPTIONS TO ALLEVIATE THEM

Gap	Applied to		Options
	Geography	Tech Phase	
North-South Collaboration	All Countries	All	• Stronger IP regimes to support strategic research partnerships, joint ventures, cross-border enterprise development • Dedicated funds and challenge programs requiring North-South collaboration • Opportunities for international study through grants, scholarships, etc. • Financial de-risking instruments to encourage foreign investment
South-South Collaboration	Developing, Emerging Countries	All	• Regional science foundations to identify common needs, pool funding and avoid research overlaps • Strengthen top-performing university networks • Create scientific and entrepreneur study abroad programs, using dedicated ODA grants
Frontier Innovation for the BOP	New Tier of Emerging Economy Innovators	Research, Development	• Dedicated international venture capital funding and risk capital for developing country start-ups, using challenge and prize programs • Training for developed country firms in understanding BOP needs, conducting demonstration tests and developing supply chains • Formal extension, cooperative and internship programs for university students
Adaptive Innovation for the BOP	All Countries	All	• To encourage BOP innovation from developed countries, including government -funded R&D, subsidies, advanced market commitments, compulsory licensing, open-source innovation, patent pools bilateral and multilateral market access agreements, and applied research networks • To encourage BOP innovation in developing countries use dedicated ODA funding to LDCs, national and community-level technology "discovery" programs, higher-education networks, strengthened IPRs, challenge programs, advanced market commitments, and applied research networks
Absorptive Innovation	All Countries	Demonstration, Deployment	• Financial support for early adopters and enterprise training programs • Adoption incentives including subsidies, tax credits and feed-in tariffs
Business Advisory Support	Developing, Emerging Countries	All	• Business services such as incubation centers, business education at technical universities, business plan competitions, deployment-focused "study abroad" programs for professors and university students, community demonstration competitions, networking events and online collaboration tools
IP Sharing and Implementation Assistance	Developing Countries	All	• Financial incentives to encourage sharing of patent information and provision of implementation assistance • Non-financial incentives to do the same (patent commons, patent pools, professional "exchange" programs for implementation advisory)
Long-Term Financial Support	Developing Countries	Demonstration, Deployment	• Financial products to de-risk investments in technology development in developing countries (e.g. first loss fund, sovereign risk insurance, concessional loans, etc.)

Source: Brookings, 2012.

APPENDIX TABLE 3

INTERNATIONAL TECHNOLOGY-FOCUSED GREEN GROWTH INITIATIVES

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Advanced Vehicle Leadership Forum (AVLF)	Government	Global	Advanced Vehicles	Research, Development, Demonstration, Deployment	An IEA program to bring together governments, cities, auto manufacturers, electric utilities and other stakeholders to systematically share information and planning on global electric vehicle and plug-in hybrid vehicle development. Among other things, the AVLF will address technical standards and practices; assess current and potential domestic and international joint RD&D efforts (particularly multicountry demonstration projects); and explore opportunities to initiate public, private and public-private R&D collaborations in the near term
Africa Rice Center	NGO	Africa	Agriculture	Research, Development	AfricaRice is a CGIAR Research Consortium Center. It is a leading pan-African rice research organization committed to improving livelihoods in Africa through strong science and effective partnerships. AfricaRice covers 24 member countries across Africa.
African Technology Policy Studies Network (ATPS)	NGO	Africa	Agriculture and Food Security, Health and Delivery, Environmental Infrastructure	Research, Development, Demonstration	ATPS organizes and implements science, technology and innovation capacity building programs at regional and national levels. It operates through national chapters in 29 countries with an expansion plan in place to cover the entire sub-Saharan Africa. All programs address science, technology and innovation capacity building priorities of African countries identified by network members and stakeholders. In each of its priority research areas, ATPS research programs focus on building national innovation systems capacities for poverty alleviation, climate change adaptation, and knowledge management and appropriation strategies.
African Union Research Grants	Government	EU, Africa	Post-Harvest and Agriculture, Renewable and Sustainable Energy, Water and Sanitation	Research, Development	The objectives of this program are to build the AU Commission capacity to create a sustainable system of competitive research grants at the pan-African level; put in place procedures and processes to manage grants within the AU Commission with the ambition to utilize the accumulated experiences of all to develop in the future a fully fledged African Framework Program for Research; and promote intra-Africa and international cooperation and collaboration in research.
Agricultural Research for Development (CIRAD)	NGO	Developing Countries	Agriculture	Research, Development	A French research center working with developing countries to tackle international agricultural and development issues. It primarily works through joint research platforms (14 worldwide and seven in the French overseas regions).
Alliance for a Green Revolution in Africa (AGRA)	NGO	Africa	Agriculture	Research, Development, Demonstration, Deployment	AGRA works to achieve a food-secure and prosperous Africa through the promotion of rapid, sustainable agricultural growth based on smallholder farmers. AGRA has six programs. It does this by financing and coordinating seed and soil R&D; disseminating information on new best practices; supporting the commercialization of new technologies; expanding networks of rural agrodealers; policy advocacy; supporting African Master's and PhD programs in agroscience; and pioneering audit and measurement systems.
AME Foundation	NGO	India	Agriculture	Demonstration, Deployment	AME Foundation is a development-oriented NGO that works with the small and marginal farmers of the Deccan Plateau region by generating farming alternatives, enriching the knowledge base, training, linking development agencies and sharing experience. AME has a FARMS Data Analysis Tool for capturing data from various agricultural programs. It hosts crop working groups and works with state agricultural university research stations. AME runs Farmer Field Schools (FFSs) and farmer trainings of various lengths and also publishes a magazine about Low External Input Sustainable Agriculture (LEISA) practices in India.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
APEC Biofuels Task Force	Government	Asia-Pacific Countries	Biofuels	Research	This group helps Asia-Pacific Economic Cooperation member economies better understand the potential for biofuels to displace oil in transport. It focuses on joint analysis of key issues affecting the development of biofuels, such as resources, economics, infrastructure, vehicles and trade opportunities.
Aqua for All	NGO	Developing Countries	Water	Research, Development, Demonstration, Deployment	Aqua for All is a foundation that acts as a networking agent, connecting public and private organizations to mobilizing resources, expertise and financing from the Dutch water sector toward development aid projects focused on water and sanitation. Though it does not implement projects, its mission is to encourage BOP water technology development and diffusion.
Asian Alliance of Appropriate Technology Practitioners (APPROTECH Asia)	NGO	Asia	Energy, Environment, Agriculture, Nutrition, Poverty Alleviation, Information Technology, Gender Issues and Emergency Response	Deployment	APPROTECH ASIA was established to increase the access of the poor to technologies and processes appropriate to their increasing needs and expanding capacities. Its primary role is to facilitate the sharing of appropriate technologies and cooperation among its member and partner organizations.
Assessments of Impacts and Adaptations to Climate Change (AIACC)	NGO	Global	Adaptation	Research, Development	AIACC funds collaborative research, training and technical support to enhance the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action. AIACC is implemented by the United Nations Environment Program and executed jointly by START and the Third World Academy of Sciences (TWAS).
Biodiversity International	NGO	Global	Agriculture, Biodiversity	Research, Development	Biodiversity International is a CGIAR Consortium Research Center. Its purpose is to investigate the conservation and use of agricultural biodiversity in order to achieve better nutrition, improve smallholders' livelihoods and enhance agricultural sustainability.
Carbon Sequestration Leadership Forum (CSLF)	Government	Developed Countries and the European Commission	Energy	Development, Demonstration, Deployment	The CSLF is a ministerial level, multilateral effort designed to advance carbon capture and storage as a viable greenhouse gas mitigation technology. The CSLF's Technical Group fosters RD&D for CCS projects reflecting its members' priorities, working with industry, government and academic experts. It has provided support for over 30 CCS projects to date.
Center for Agricultural Biosciences International (CABI)	NGO	Developing Countries	Agriculture, Biodiversity	Research, Development	An international science-based development and information organization that does field and academic research, research dissemination via databases, and maintenance of a physical directory of information on genetic diversity. It leads the CIMRC Consortium, which manages the DFID Research4Development portal, a free online database on all research that DFID supports.
Center for Biodiversity and Indigenous Knowledge (CBIK)	NGO	China	Climate Change, Biodiversity, Agriculture, Water	Deployment	CBIK aims to explore alternative development approaches that work directly with indigenous people in Southwest China. It conducts interdisciplinary research, facilitation for participatory development, consultation for cultural identity, networking for information sharing, and capacity building for watershed governance and livelihood development.
Center for Global International Agriculture Research (CGIAR)	NGO	Global	Agriculture, Water, Adaptation	Research, Development	CGIAR is global research alliance of 64 governments, private foundations, and international and regional organizations working to reduce poverty alleviation, hunger, and malnutrition and ensure sustainable development through improved agriculture. It operates a network of 15 research centers and three challenge programs related to water and food, and unlocking crop genetic diversity .The latter challenge program has an implementation requirement.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Center for Innovation, Entrepreneurship and Technology (CIETEC) Brazil	Public-Private Partnership	Brazil	Companies with a public purpose	Research, Development	In the absence of a private venture capital market in Brazil, there is a "vast network of incubator centers, technology parks and universities" that receive public funding to support small and medium enterprise innovation and R&D. As of 2010, 350 companies had received support.
Center for International Forestry Research (CIFOR)	NGO	Global	Forestry	Research, Development, Demonstration, Deployment	CIFOR is a CGIAR research center devoted to the sustained well-being of people in developing countries, particularly in the tropics, in forested regions. It achieves this through collaborative, strategic and applied research and by promoting the transfer and adoption of appropriate new technologies and social systems for national development. Among its mandates are the improvement of the scientific basis that underpins forest management and the development of policies and technologies for sustainable use and management of forest goods and services.
Central American and Mexico Coniferous Resources Cooperative (CAMCORE)	NGO	Central America	Forestry, Biodiversity	Research	CAMCORE is a nonprofit, international program that works for the conservation of tropical and subtropical forest tree species. Our primary activities are to: Identify threatened species and provenances; collect seeds from these vulnerable populations; distribute seeds for ex situ conservation and growth studies; assess genetic diversity to improve methods of in situ conservation; evaluate adaptability and growth of trees in various locations; and develop long-term improvement programs to ensure sustainability of resources.
Center for Research and Information on Low External Input and Sustainable Agriculture (ILEIA)	NGO	Global	Agriculture	Research	ILEIA supports the search for sustainable alternatives to conventional high-input agriculture by collecting, analyzing and exchanging information on practical experiences of small farmers, particularly in the South. ILEIA cooperates with many other organizations and individuals in promoting ecologically sound agriculture throughout the world.
Centro Internacional de Agricultural Tropical (CIAT)	NGO	Tropical Countries	Agriculture	Research, Development	CIAT is a CGIAR Research Consortium Center. Its mission is to reduce hunger and poverty and to improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture. Interdisciplinary and applied research will be conducted through partnerships with national programs, civil society organizations and the private sector to produce international public goods that are directly relevant to their users. These goods include improved germplasm, technologies, methodologies and knowledge.
Collaborative Labeling and Standards Program (CLASP)	NGO	Global	Energy Efficiency	Deployment	CLASP's mission is to promote energy efficiency standards and labels for appliances, equipment and lighting. In 2011, CLASP joined the intergovernmental Super-efficient Equipment and Appliance Deployment (SEAD) Initiative as the operating agent. SEAD is a government-led market transformation effort for highly efficient appliances and equipment.
International Partnership for Energy Efficiency Cooperation (IPEEC)	Government	Global	Renewable Energy, Energy Efficiency	Demonstration, Deployment	The IPEEC promotes energy efficiency worldwide by exchanging information related to energy efficiency, developing partnerships between energy efficiency actors, and supporting energy efficient initiatives. IPEEC supported initiatives are open to member and nonmember nations as well as the private sector.
Climate Renewables and Efficiency Demonstration Initiative (REDI)	Government	Global	Energy efficiency	Deployment	This program will support the Major Economies Forum (MEF) Technology Action Plans aimed at accelerating the demonstration of low-emission technologies, including super efficient appliances and solar household appliances in developing countries. It consists of three primary programs: SEAD (Super Efficient Equipment & Appliance Program), SLED (Solar & LED Lighting Program), and the Clean Energy Information Platform.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Conservation International	NGO	Global	Climate Change, Agriculture, Health, Water, Forestry, Biodiversity	Research, Development, Demonstration, Deployment	Conservation International is an international NGO working to promote the conservation of land and aquatic ecosystems. It does this by showing how environmental policy and governance, innovative market and incentive mechanisms for protecting biodiversity and engaged civil society groups are essential for sustainable social and economic development. As part of its work, it develops field demonstrations in specific geographies where the relationship among healthy ecosystems, ecosystem services and human well-being can be maximized.
Coordinated Low Emissions Assistance Network (CLEAN)	Government	Global, Developing Countries	Climate Change, Alternative Energy, Renewable Energy	Research, Development, Demonstration	CLEAN's aim supports national and international organizations that assist developing countries with preparation and implementation of comprehensive low-GHG emission development plans and strategies. This includes support for technology needs assessments, low-carbon and clean energy development plans, technology roadmaps and low-carbon technology demonstration programs. It has a plan to develop an inventory of activities that CLEAN partners are conducting at country, regional and global levels to support low carbon development assessment and plans.
Danida Forest Seed Center (DFSC)	Government	Developing Countries	Forestry	Demonstration, Deployment	DFSC is an institution administered by the Danish International Development Administration. It provides advice and guidance on seed procurement, tree improvement, conservation of forest genetic resources for tropical and subtropical developing countries
Deshpande Center for Technology Innovation	NGO	U.S.	Various	Research, Development, Demonstration	The Deshpande Center is part of the MIT School of Engineering and was created to increase the impact of MIT technologies in the marketplace. It disburses grants, brings in volunteer consultants, compiles teams of business and engineering students to write business plans, hosts events, and offers an X-Prize Lab at MIT.
Energy+	NGO	Developing Countries	Renewable Energy, Energy Efficiency, Energy Access	Research, Development, Demonstration, Deployment	The Energy+ Initiative engages with developing countries to support transformative change to increase energy access at scale and avoid/reduce energy sector greenhouse gas emissions relative to a business-as-usual baseline, by applying a result-based sector level approach, and leveraging private capital and carbon market financing.
EU Ideas Program—EU Framework Program	Government	EU	All Categories	Research	Supports frontier research on the basis of scientific excellence. Research may be carried out in any area of science and there is no obligation for cross-border partnerships. The program is implemented via the European Research Council.
EU People Program (Marie Curie)—EU Framework Program	Government	EU	All Categories	Research, Development	The EU People Program works by strengthening, quantitatively and qualitatively, the human potential in research and technology in Europe, by stimulating people to enter into the profession of researcher, encouraging European researchers to stay in Europe, and attracting to Europe researchers from the entire world, making Europe more attractive to the best researchers.
European Institute of Innovation and Technology—InnoEnergy	Public-Private Partnership	EU (explicitly including Eastern Europe)	Renewable Energy, Energy Efficiency, Electricity Grid/Storage, Clean Coal and CCS	Development, Demonstration, Deployment	The mission of the EIT is to grow and capitalize on the innovation capacity and capability of actors from higher education, research, business and entrepreneurship from the EU and beyond through the creation of highly integrated Knowledge and Innovation Communities (KICs).
European Institute of Innovation and Technology—Climate KIC	Public-Private Partnership	EU (explicitly including Eastern Europe)	Water, Climate Science, Cities, Biofuels/ Chemicals	Development, Demonstration, Deployment	The mission of the EIT is to grow and capitalize on the innovation capacity and capability of actors from higher education, research, business and entrepreneurship from the EU and beyond through the creation of highly integrated Knowledge and Innovation Communities (KICs)

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
EU Joint Technology Initiative Aeronautics and Air Transport (Clean Sky)—EU Framework Program (Cooperation Program)	Public-Private Partnership	EU	Transport (Air Transport)	Development, Demonstration, Deployment	Clean Sky aims to develop and mature breakthrough 'clean technologies' for Air Transport, to contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.
EU Joint Technology Initiative Fuel Cells and Hydrogen (FCH)—EU Framework Program (Cooperation Program)	Public-Private Partnership	EU	Transport, Clean Energy	Development, Demonstration, Deployment	FCH aims to speed up the development of fuel cells and hydrogen technologies in Europe in order to enable their commercial deployment between 2010 and 2020.
EU Research Infrastructure—EU Framework Program (Capacities Program)	Government	EU	Various	Research, Development, Demonstration	The overall objective of the 'Research infrastructures' part of the Seventh Framework Program (FP7) Capacities program is to optimize the use and development of the best research infrastructures existing in Europe. Furthermore, it aims to help to create new research infrastructures of pan-European interest in all fields of science and technology. The European scientific community needs these to remain at the forefront of the advancement of research, and they will help industry to strengthen its base of knowledge and technological know how.
EU Research for the Benefit of SMEs—EU Framework Program (Capacities Program)	Government	EU	Various	Research, Development, Demonstration	The aim is to strengthen the 'innovation capacity' of small and medium-sized enterprises in Europe and their contribution to the development of new technology-based products and markets. The program will help them outsource research, increase their research efforts, extend their networks, better exploit research results and acquire technological know how, bridging the gap between research and innovation.
EU Regions of Knowledge—EU Framework Program (Capacities Program)	Government	EU (explicitly including Eastern Europe)	Various	Research, Development, Demonstration	The Regions of Knowledge initiative aims to strengthen the research potential of European regions, in particular by encouraging and supporting the development across Europe of regional 'research-driven clusters', associating universities, research centers, enterprises and regional authorities.
EU Research Potential for Convergence Regions—EU Framework Program (Capacities Program)	Government	EU (explicitly including Eastern Europe)	Various	Research, Development, Demonstration	This initiative aims to stimulate the realization of the full research potential of the enlarged European Union by unlocking and developing the research potential in the EU´s 'convergence regions' and outermost regions, and helping to strengthen the capacities of their researchers to successfully participate in research activities at EU level.
EU Science in Society—EU Framework Program (Capacities Program)	Government	EU	Various	Research, Development, Demonstration	With a view to building an effective and democratic European knowledge-based society, EU Science in Society aims to stimulate the harmonious integration of scientific and technological endeavors, as well as associated research policies into European society.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
EU Coherent Development of Policies—EU Framework Program (Capacities Program)	Government	EU (explicitly including Eastern Europe)	Various	Research, Development, Demonstration	This action aims to enhance the effectiveness and coherence of national and European Community research policies and their articulation with other policies, improving the impact of public research and its links with industry, and strengthening public support and its leverage effect on investment by private actors.
EU International Cooperation—EU Framework Program (Capacities Program)	Government	EU	Various	Research, Development, Demonstration	This initiative aims to help Europe become more competitive and play a leading role globally by creating a strong and coherent international science and technology policy.
EU Competitiveness and Innovation Program (CIP)	Government	EU	Various	Research, Development, Demonstration	With small and medium-sized enterprises as its main target, the Competitiveness and Innovation Framework Program supports innovation activities (including eco-innovation), provides better access to finance, and delivers business support services.
EU Lead Markets Initiative	Government	EU	Sustainable Construction, Recycling, Bio-Based Products, Renewable Energy	Deployment (Innovation Pull)	Aim to unlock market potential for innovative goods and services by lifting obstacles hindering innovation in a first batch of six important markets: eHealth, protective textiles, sustainable construction, recycling, bio-based products and renewable energies.
EU Green Cars—European Economic Recovery Plan	Public-Private Partnership	EU	Transport (Road)	Research, Development	The European Green Cars initiative is one of the three public-private partnerships included in the commission's recovery package. The envelope for this initiative is foreseen at €5 billion to boost to the automotive industry in a time of economic hardship, and support the development of new, sustainable forms of road transport.
EU Factories of the Future—European Economic Recovery Plan	Public-Private Partnership	EU	Industry (Manufacturing)	Research, Development	Factories of the Future is one of the three public-private partnership included in the commission's recovery package. It consists of a research program of €1.2 billion to support the manufacturing industry in the development of new and sustainable technologies. The program will be financed jointly by industry and the European Commission under the Seventh Framework Program.
EU Energy Efficiency Building—European Economic Recovery Plan	Public-Private Partnership	EU	Energy Efficiency (Building)	Research, Development	Energy-efficient buildings consists of a financial envelope of €1 billion to boost the construction sector. It aims at promoting green technologies and the development of energy efficient systems and materials in new and renovated buildings, with a view to radically reducing their energy consumption and CO_2 emissions.
European Technology Platform for Renewable Heat and Cooling—EU Framework Program	Government	EU	Renewable Energy	Research, Development, Demonstration	The European Technology Platform on Renewable Heating and Cooling, officially endorsed by the European Commission since October 2008, aims at playing a decisive role in maximizing synergies and strengthening efforts towards research, development and technological innovation which will consolidate Europe's leading position in the sector.
European Technology Platform for Photovoltaics—EU Framework Program	Government	EU	Renewable Energy	Research, Development, Demonstration	The Photovoltaic Technology Platform is a European initiative that aims at mobilizing all the actors sharing a long-term European vision for photovoltaic; realizing the European Strategic Research Agenda for photovoltaic for the next decade(s) and give recommendations for implementation; and ensuring that Europe maintains industrial leadership.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
European Technology Platform for the Electricity Networks of the Future (SmartGrids)—EU Framework Program	Government	EU	Electricity Networks	Research, Development, Demonstration	This initiative aims to foster and support the deployment of SmartGrids in Europe by advising and providing coordination to the various SmartGrids Forum stakeholders (European Commission, Transmission Service Operators, Distribution system Operators, Energy System and Component providers, Energy Research Centers, Smart Metering Industry, Energy Consumers, Utilities Telecom Providers, Grid Regulators) among projects and related initiatives, to facilitate the smooth and efficient running of the European Technology Platform SmartGrids ensuring its strategic relevance and its consistency with EU policy.
European Technology Platform for Water (WssTP)—EU Framework Program	Government	EU	Water	Research, Development, Demonstration	WssTP aims to promote coordination and collaboration of Research and Technology Development in the water industry. Through its strategic research agenda WssTP provides strategic answers for the water research future challenges. It has 70 members and 210 contributors from industries, academics, research, policymakers and water utilities.
European Technology Platform for Sustainable Farm Animal Breeding and Reproduction (FABRE-TP)—EU Framework Program	Government	EU	Agriculture	Research, Development, Demonstration	The Technology Platform is industry led, with strong involvement of many stakeholders. A vision paper for the next 10-25 years has been developed, and was signed by European Commission Research Commissioner Potočnik. The management of approximately 120 organizations have committed themselves to the Sustainable Far Animal Breeding and Reproduction Technology Platform (FABRE-TP) Vision. Based on the vision, a strategic research agenda and an implementation plan have been developed. European Commission supported this activity by means of a project.
European Technology Platform for Global Animal Health (ETPGAH)—EU Framework Program	Government	EU	Agriculture	Research, Development, Demonstration	ETPGAH aims to provide a mechanism for focusing and prioritizing the research that ultimately delivers new or improved tools such as veterinary vaccines and diagnostic tests. It will also help to speed up the delivery of new products to the market by overcoming the constraints identified throughout the supply chain.
European Technology Platform 'Plants for the Future'—EU Framework Program	Government	EU	Agriculture, Food Security	Research, Development, Demonstration	Plants for the Future is a stakeholder forum for the plant sector with members from industry, academia and the farming community. It serves as a platform for all stakeholders concerned with plants to provide their views and represent their interests in an open discussion process. It provides a 20-year vision and a short-, medium- and long-term strategic research agenda for Europe's plant sector setting out a consensus on the research needed to fulfill the vision.
European Construction Technology Platform—ECTP—EU Framework Program (Cooperation Program)	Government	EU	Energy Efficiency (Building)	Research, Development, Demonstration	ECTP will analyze the major challenges that the sector faces in terms of society, sustainability and technological development. Research and innovation strategies will be developed to meet these challenges engaging with and mobilizing the wide range of leading skills, expertise and talent available to us within our industry over the coming decades, in order to meet the needs of the society.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
European Steel Technology Platform—ESTEP—EU Framework Program (Cooperation Program)	Government	EU	Industry (Steel)	Research, Development, Demonstration	ESTEP brings together all the major stakeholders in the European steel industry. Our membership includes major steel manufacturers; universities and research institutions active in steel research; major users of steel such as car manufacturers; and public bodies like the European Commission and national governments—all which have great interest in this vital industrial sector that is so important for Europe's future.
European Technology Platform on Sustainable Mineral Resources—ETP SMR—EU Framework Program (Cooperation Program)	Government	EU	Industry (Mining)	Research, Development, Demonstration	The Goal of the ETP SMR is to modernize and reshape one of the fundamental pillars of the European economy and society: the European extracting and processing sector of energy and non-energy minerals. They aim to achieve all the environments, societal and economic benefits.
European Technology Platform for Future Manufacturing Technologies – Manufuture—EU Framework Program (Cooperation Program)	Government	EU	Industry (Manufacturing)	Research, Development, Demonstration	The mission of the European Technology Platform Manufuture is to propose, develop and implement a strategy based on research and innovation that is capable of speeding up the rate of industrial transformation to high value-added products, processes and services, securing high-skills employment and winning a major share of world manufacturing output in the future knowledge-driven economy.
European Technology Platform for Sustainable Chemistry – SusChem—EU Framework Program (Cooperation Program)	Government	EU	Industry (Chemicals)	Research, Development, Demonstration	SusChem addresses challenges that are specific to the European chemical and industrial biotechnology industry, but also addresses challenges that apply to European society as a whole. To achieve this vision, SusChem brings together people from across the chemical community and wider society to formulate research and innovation roadmaps.
European Technology Platform for Advanced Engineering Materials and Technologies – EuMaT—EU Framework Program (Cooperation Program)	Government	EU	Industry	Research, Development, Demonstration	EuMaT was launched in order to assure optimal involvement of industry and other important stakeholders in the process of establishing of R&D priorities in the area of advanced engineering materials and technologies. EuMaT should improve coherence in existing and forthcoming EU projects in the field of materials R&D.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
EU Advisory Council for Aeronautics Research in Europe—ACARE—EU Framework Program (Cooperation Program)	Government	EU	Transport (Air Transport)	Research, Development, Demonstration	ACARE is the Advisory Council for Aviation Research and innovation in Europe and provides a network for strategic research in aeronautics and air transport so that aviation satisfies the needs of society and secures global leadership for Europe in this important sector.
EU European Rail Research Advisory Council—ERRAC—EU Framework Program (Cooperation Program)	Government	EU	Transport (Rail)	Research, Development, Demonstration	ERRAC was set up in 2001 with the ambitious goal of creating a single European body with both the competence and capability to help revitalize the European rail sector and make it more competitive, by fostering increased innovation and guiding research efforts at European level.
EU European Road Transport Research Advisory Council—ERTRAC—EU Framework Program (Cooperation Program)	Government	EU	Transport (Road)	Research, Development, Demonstration	ERTRAC was established to mobilize the stakeholders of the Road Transport System, to develop a shared vision and to ensure a timely, coordinated and efficient implementation of research in Europe, with the objective to tackle the societal challenges of road transport and to enhance the European competitiveness.
EU Waterborne ETP – Waterborne—EU Framework Program (Cooperation Program)	Government	EU	Transport (Shipping)	Research, Development, Demonstration	Waterborne is a forum where all stakeholders from the waterborne sector (sea & inland) define and share a common vision and a strategic research agenda, driving the necessary innovation efforts forward.
EU Collaborative Research (Grants)—EU Framework Program (Cooperation Program)	Government	EU	All categories	Research, Development	This granting program fosters collaborative research by transnational consortia of industry and academia. Research is carried out in 10 key thematic areas: health; food, agriculture and fisheries and biotechnology; information and communications technologies; nanosciences, nanotechnologies, materials and new production technologies; energy; environment (including climate change); transport (including aeronautics); socio-economic sciences and the humanities; and space and security.
European Forestry Institute	NGO	EU	Forestry	Research	An independent NGO conducting forestry research in Europe. Its mission is to promote, conduct and cooperate in research of forestry and forest products at the pan-European level and to make the results of the research known to all interested parties, notably in the areas of policy formulation and implementation, in order to promote the conservation and sustainable management of forests in Europe.
European Tropical Forest Research Network (ETFRN)	Government	Tropical Countries	Forestry	Research, Development, Demonstration, Deployment	The European Tropical Forest Research Network is a forum for communication between public and private organizations concerned with (subtropical forest research. The ETFRN Network seeks to promote the involvement of European research expertise towards the conservation and wise use of forests and woodlands in tropical and subtropical countries.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
European Union Biofuels Technology Platform	Government	EU	Biofuels	Research, Development, Demonstration	European Union Biofuels Technology Platform engages with biofuels stakeholders, research projects funded by the European Commission and global biofuels organizations in a range of activities relevant to the RD&D of sustainable advanced biofuels in Europe. The platform produces a strategic research agenda, and conducts mapping of research and demonstration activities.
European Union Zero Emissions Platform (ZEP)	Government	EU	Climate Change	Research, Demonstration	European Union Zero Emissions Platform provides advice to the European Commission on technical, policy and commercial matters related to expansion of CCS to meet EU targets. The ZEP involves industry and other stakeholders on all technology issues, including recommendations for next generation CCS technologies.
Forest-based Sector Technology Platform (FTP)—EU Framework Program	Government	EU	Forestry	Research, Development, Demonstration	FTP is a joint initiative of the European forest-based sector and was set up in 2005 to define a vision for the future of the forest-based sector. It is one of around 30 European technology platforms established as industry-led initiatives with EU support and its overall aim is to promote joint European cooperation on research and innovation
Global Bioenergy Partnership (GBEP)	NGO	Global	Climate Change, Agriculture, Energy Security	Research, Development, Demonstration, Deployment	It brings together bioenergy stakeholders to organize, coordinate and implement targeted international RD&D and commercial activities related to production, delivery, conversion and use of biomass for energy, with a focus on developing countries. The GBEP has made progress developing sustainability criteria, as well as indicators and a methodological framework for measuring greenhouse gas savings.
Global Carbon Capture and Storage Institute	NGO	Global	Climate Change	Research, Development	Global Carbon Capture and Storage Institute is an international RDD&D center for CCS that was initially funded by the Australian Government and now consists of more than 300 government, corporate and NGO members. Its primary focus is on accelerating the adoption of CCS technology through large-scale demonstration. Global CCS Institute activities include knowledge sharing, strategic analysis to fill gaps in knowledge and project funding and support.
Global Climate Adaptation Partnership	NGO	Developing Countries	Adaptation	Diffusion	The Global Climate Adaptation Partnership established the Adaptation Academy as an intensive training program to enable professionals to be effective in the areas of climate data and information use, risk and vulnerability assessment and communication, adaptation planning, decision-making, monitoring and evaluation in policy and practice. It has a collaborative research component.
Global Development Network (GDN)	NGO	Global	Various	Research, Development	GDN promotes the generation, sharing and application to policy of multidisciplinary knowledge for the purpose of development. GDN works in collaboration with 11 regional partners. Eight regional partners are based in developing and transition countries and three in developed countries. GDN is a worldwide network of research institutes, academic institutions, think tanks and more than 8,000 individual researchers worldwide.
Global Innovation through Science & Technology (GIST)	NGO	Middle East, North Africa, Asia	Various	Research, Development, Demonstration	The Global Innovation through Science and Technology initiative was established in 2010, with funding from the U.S. Department of State, to spur economic advancement through science and technology-based innovation in countries across the Middle East, North Africa and Asia. It runs a technology competition, business plan competition in collaboration with the MIT Enterprise Forum for the Pan-Arab region, and a "Start-Up boot camp".
Global Water Initiative	NGO	Central America, West Africa, East Africa	Water	Demonstration, Deployment	Global Water Initiative is a coalition of seven international organizations with a plan to change the landscape of water, sanitation and hygiene services in 13 countries in Central America, West Africa and East Africa. For a minimum of 10 years, these partners will address the challenges of providing long-term access to clean water and sanitation for homes and livelihoods, while promoting the protection and sustainable management of ecosystems.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Ibero-Amercan Science and Technology Education Consortium (ISTEC)	NGO	Spain, Portugal	General Science, Technology and Innovation	Research, Development, Demonstration, Deployment	ISTEC's mission is to foster sustainable socio-economic development in Ibero-America by carrying out programs focused on higher education in STEM subjects, fostering knowledge sharing, supporting joint R&D, and creating a supportive entrepreneurial environment. Two programs of note are its Los Libertadores Centers of Excellence, which includes work streams for natural resource management, and its Science & Technology Entrepreneurship for Economic Development (STEED) Program.
IDRC Challenge Fund	NGO	Canada, Global	Agriculture and Environment, Health, Social and Economic Policy, Science Technology and Innovation	Research, Development	The Challenge Fund creates opportunities for researchers to work in multinational collaborative teams. Four of its five initiatives relate to the environment, and almost all teams pair a Canadian research university with a developing or emerging country research university.
IDRC: Innovation for Inclusive Development	NGO	Canada, Global	Natural Resources, Women's Rights, Cultural Industries, The Role of Intermediaries	Research	Innovation for Inclusive Development is a research grant program of the IDRC that funds projects for knowledge generation, capacity building, field building and policy influence. Topical areas of support include: innovation in natural resource management, cultural industries, and service sectors; innovation and women in the informal economy; and the roles of intermediaries.
IEA Clean Coal Center	Government	Global	Energy	Research, Development	Created by an IEA Implementing Agreement, the center is an authoritative source of reports, in-depth reviews and databases on the energy-efficient and environmentally sustainable use of coal (including co-firing coal with waste or biomass). Recently released reports cover topics such as: the capture of CO_2 with other air pollutants; co-gasification and indirect cofiring of coal and biomass; the performance and risks of advanced pulverized coal plants; and underground coal gasification.
IEA Greenhouse Gas R&D Program (IEAGHG)	Government	IEA Member Countries	Climate Change, Energy	Research, Development, Demonstration	The IEA Greenhouse Gas R&D Program is an international collaborative research program established in 1991 as an Implementing Agreement under the International Energy Agency (IEA). The role of the Program is to evaluate technologies that can reduce greenhouse gas emissions derived from the use of fossil fuels. It also operates a dozen research networks around subtopical areas such as $C0_2$ capture and modeling.
IEA Implementing Agreement—Cooperating Program on Efficient Electrical End-Use Equipment (4E)	Government	Global	Energy Efficiency	Research, Development, Demonstration	4E is designed to fill the need for countries to share expertise, to ensure coordination of international initiatives aimed at implementing efficiency improvements in end-use electrical equipment. Specifically, it aims to encourage greater international cooperation for efficient equipment policies and to promote the best available technologies.
IEA Implementing Agreement—Industrial Energy-related Technologies and Systems (IETS IA)	Government	Global	Energy Efficiency	Research, Development, Demonstration	The mission of IETS is to foster international cooperation among OECD and non-OECD countries for accelerated R&D of industrial energy-related technologies and systems, predominantly for end use. It currently focuses on the most energy intensive industries but is moving to expand research in other sectors and to facilitate cooperation in industrial RD&D.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
IEA Implementing Agreement—Research, Development, Demonstration and Promotion of Heat Pumping Technologies (Heat Pumps IA)	Government	15 OECD Countries	Energy Efficiency	Research, Development, Demonstration	Heat Pumps IA conducts research, provides information sharing, offers program support to member countries undertaking R&D projects related to heat pump efficiency.
IEA Implementing Agreement—Co-operation on Hybrid and Electric Vehicle Technologies and Programs (HEV IA)	Government	Global	Advanced Vehicles	Research, Development, Demonstration, Deployment	HEV IA conducts research, provides information sharing, offers program support to member countries undertaking R&D projects related to hybrid and electric vehicle technologies.
IEA Implementing Agreement—Co-operation on Technologies and Programs for Demand-Side Management (DSM IA),	Governemnt	Global	Energy Efficiency	Research, Development, Demonstration	The IEA Demand-Side Management Program is an international collaboration of 20 countries working together to develop and promote opportunities for demand-side management
IEA Implementing Agreement—District Heating and Cooling, including the Integration of Combined Heat and Power (DHC IA),	Government	9 Countries	Energy Efficiency	Research, Development, Demonstration	DHC IA's mission is to conduct research and development as well as policy analysis of district heating and cooling systems with low environmental impact through international collaboration. It selects, manages, and publishes collaborative results of co-funded R&D projects between countries.
IEA Implementing Agreement—Program to Develop and Test Solar Heating and Cooling Systems (SHC IA)	Government	Global	Energy Efficiency	Research, Development, Demonstration	SHC IA conducts analyses, coordinates R&D projects, provides information sharing, offers program support to member countries undertaking R&D projects related to solar heating and cooling. It sponsors an annual SHC Solar Award to recognize the research contributions of one SHC individual or institution to the field and to the program.
IEA Implementing Agreement—Research and Development on Energy Conservation in Buildings and Community Systems (ECBCS IA)	Government	Global	Energy Efficiency	Research, Development, Demonstration	ECBCS' mission is to develop and facilitate the integration of technologies and processes for energy efficiency. It does this by carrying out research and development activities toward near-zero energy and carbon emissions in the built environment and disseminating its results through seminars, conferences, and online reports. Activities usually take the form of a 'Task Shared' Annex in which each country commits an agreed level of effort.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
IEA Implementing Agreement—Research and Development on Energy Conservation through Energy Storage (ECES IA),	Government	5 OECD Countries	Energy Efficiency	Research, Development, Demonstration	ECES' mission is to undertake cooperative research, development, demonstrations and exchange of information in the area of energy storage.
Implementing Agreement for a Climate Technology Initiative (CTI)	Government	Global	Climate Change	Research, Development, Demonstration	CTI's mission is to bring countries together to foster international cooperation in the accelerated development and deployment of climate friendly and environmentally sound technologies and practices. The CTI works closely with the United Nations Framework Convention on Climate Change (UNFCCC) process. Activities include: technology needs assessments, seminars, implementation, training courses and information dissemination.
Implementing Agreement for a Program of Research and Demonstration on Advanced Motor Fuels (AMF IA)	Government	IEA Member Countries	Advanced Vehicles	Research, Development, Demonstration	Its goal is to facilitate the market introduction of advanced motor fuels and related vehicle technologies in IEA member countries. In addition to a current project assessing the emissions from use of ethanol as a motor fuel, the AMF IA is also conducting research on biomass-derived diesel fuels, fuel and technology alternatives for buses, and particle emissions of scooters.
Implementing Agreement for a Programmof Research and Development on Advanced Materials for Transportation Applications (AMT IA)	Governemnt	5 Countries	Advanced Vehicles	Research, Development	AMTIA cooperates internationally to share information on technologies to reduce surface friction and weight, for example through the use of magnesium alloys, low-cost carbon fibers, and nano-composites. There are currently five countries participating, including China.
Implementing Agreement for a Program of Research, Development and Demonstration on Advanced Fuel Cells (AFC IA)	Government	19 Countries	Advanced Vehicles	Research, Development	Its current projects include measurement and monitoring techniques, exchange of information on cell, stack and system performance, collaboration on the development of new procedures and models, and information sharing on application requirements. Nineteen countries participate, including Mexico.
Implementing Agreement for a Program of Research, Development and Demonstration on Bioenergy (Bioenergy IA)	Government	22 Countries	Bioenergy	Research, Development, Demonstration	Consisting of 22 contracting national parties, Bioenergy IA focuses on the full range of bioenergy RD&D.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Implementing Agreement for Co-operation in the Research, Development and Demonstration of Wind Energy Systems (Wind IA)	Government	Global	Renewable Energy	Research, Development, Demonstration	The IEA Wind Agreement sponsors cooperative research tasks and provides a forum for international discussion of research and development issues.
Indo-German Watershed Development Program	Government	India	Agriculture, Water	Demonstration, Deployment	A government supported watershed development program implemented by the nonprofit organization, the Watershed Organization Trust, along with the Indian government's National Bank for Agriculture and Rural Development. The program funds village-based, participatory watershed development projects to promote soil and water conservation. To qualify, villages must agree to temporary bans on tree-cutting and grazing on land designated for regeneration. They must also contribute free labor—a common rural practice known as shramdan—to cover at least 15-20 percent of project costs
Inkaba ye Africa	Government	South Africa	Climate Change, Natural Resource Management	Research	Inkaba ye Africa is a Germany-South Africa Earth Science Collaborative for "next generation science and technology and capacity building." The partnership provides research grants to post-graduate students and coordinates earth science trainings. In its second phase, it plans to expand to other African countries.
Innovation Prize for Africa	Government	Africa	Energy, Water, Health, Agriculture	Research, Development, Demonstration, Deployment	The 2012 prize is the first of an annual, five-year joint initiative of the United Nations Economic Commission for Africa and the African Innovation Foundation. It aims to promote innovation across Africa in key sectors of interest through the competition; promote science, technology and engineering as rewarding, exciting and noble career options among the youth in Africa by profiling successful applicants; and encourage entrepreneurs, innovators, funding bodies and business development service providers to exchange ideas and explore innovative business opportunities.
Institute for Connectivity in the Americas (ICA)	NGO	Latin America	Information Technology	Diffusion	ICA is a hemispheric organization that promotes the implementation of innovative uses of information and communication technologies for development. It co-funds projects, enables partnerships, and supports knowledge creation and capacity building. Its primary objective is to encourage research beyond the scope of national programs by advancing comparative and focused studies based on scientific issues important to the region as a whole.
Inter-American Institute for Global Change Research	Government	Global	Agriculture, Land-Use. Forestry, Water and Climate Science	Research	The IAI is an intergovernmental organization supported by 19 countries in the Americas dedicated to pursuing the principles of scientific excellence, international cooperation, and the full and open exchange of scientific information to increase the understanding of global change phenomena and their socio-economic implications.
International Center for Agricultural Resources in Dry Areas (ICARDA)	NGO	Global	Agriculture	Research, Development	ICARDA has a global mandate for the improvement of barley, lentil and faba bean and serves the nontropical dry areas for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)	NGO	Asia, Sub-Saharan Africa	Agriculture	Research, Development	ICRISAT is a CGIAR Research Consortium Center. ICRISAT conducts research on five highly nutritious, drought-tolerant crops—chickpea, pigeon pea, pearl millet, sorghum and groundnut. It also develops sustainable management of semi-arid tropic systems through efficient and sustainable management of natural resources, and enables policies and institutions for improving livelihoods and achieving food, nutrition and health security while protecting the environment.
International Food Policy Research Institute	NGO	Global	Agriculture	Research, Development	IFPRI is a CGIAR Research Consortium Center. Its mission is to achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, livestock, forestry, fisheries, policy and natural resources management.
International Geothermal Partnership (IPGT)	Government	Australia, Iceland, U.S.	Renewable Energy	Research, Development, Demonstration	IPGT's mission is to accelerate the development of geothermal technology. IPGT provides a forum for government and industry leaders to coordinate efforts to develop new technologies and pursue projects. Partners share information on results and best practices to avoid blind alleys and limit unnecessary duplication.
International Institute of Tropical Agriculture	NGO	Tropical Countries	Agriculture	Research, Development	ITTA is a CGIAR Research Consortium Center. ITTA conducts research on the following crops: cowpea, soybean, banana/plantain, yam, cassava and maize. It works with partners in Africa and beyond to reduce producer and consumer risks, enhance crop quality and productivity, and generate wealth from agriculture.
International Livestock Research Institute	NGO	Asia, Africa	Agriculture	Research, Development	ILRI is a CGIAR Research Consortium Center. It works with partners to help poor people keep their farm animals alive and productive, increase and sustain their livestock and farm productivity and find profitable markets for their animal products.
International Maize & Wheat Improvement Center (CIMMYT)	NGO	Developing Countries	Agriculture	Research, Development	CIMMYT is a CGIAR Research Consortium Center. Its mission is to sustainably increase the productivity of maize and wheat systems to ensure global food security and reduce poverty. Conventional maize and wheat breeding is at the heart of CIMMYT's work and accomplishments. It grew out of a pilot program in Mexico started in 1943.
International Partnership for Energy Efficiency Co-operation (IPEEC)	Government	Global	Energy Efficiency	Research, Development	The International Partnership for Energy Efficiency Cooperation (IPEEC) is a high-level international forum that provides global leadership on energy efficiency by identifying and facilitating government implementation of policies and programs that yield high energy-efficiency gains. IPEEC also aims to promote information exchange on best practices and facilitate initiatives to improve energy efficiency
International Potato Center	NGO	Developing Countries	Agriculture	Research, Development	The International Potato Center is a CGIAR Research Consortium Center that works with partners to achieve food security, well-being, and gender equity for poor people in root and tuber farming and food systems in the developing world through research and innovation in science, technology, and capacity strengthening.
International Rice Research Institute (IRRI)	NGO	Global	Agriculture	Research, Development	IRRI is a CGIAR Research Consortium Center. It develops new rice varieties and rice crop management techniques that help rice farmers improve the yield and quality of their rice in an environmentally sustainable way. It works with our public and private sector partners in national agricultural research and extension systems in major rice-growing countries to do research, training, knowledge transfer, and policy formation.
International Seed Testing Association (ISTA)	NGO	Global	Agriculture	Research, Development	The ISTA develops and publishes standard procedures in the field of seed testing. It has member laboratories in over 70 countries worldwide.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
International Thermonuclear Experimental Reactor (ITER)	Government	China, EU, India, Japan, U.S., Korea, Russia	Renewable Energy, Energy Efficiency	Research, Development	ITER is an international project to design and build an experimental fusion reactor that aims to produce up to 500 MW from fusion power. The key elements for power generation are currently being researched in the national research facilities of the contracting parties to the IEA Fusion Implementing Agreements under the guidance of the IEA Fusion Power Coordinating Committee.
International Union of Forest Research Organizations (IUFRO)	NGO	Global	Forestry	Research	IUFRO is a nonprofit, nongovernmental international network of forest scientists, which promotes global cooperation in forest-related research and enhances the understanding of the ecological, economic and social aspects of forests and trees. It unites more than 15,000 scientists in almost 700 member organizations in over 110 countries, and is a member of ICSU.
International Water Management Institute (IWMI)	NGO	Asia, Africa	Water, Agriculture	Research, Development	IWMI is a nonprofit organization and CGIAR research institute whose mission is to improve the management of land and water resources for food, livelihoods and the environment. Research is the core activity with a research agenda is organized around four priority themes including water availability and access; productive water use; water quality, health and environment; and water and society.
International Waters Learning Exchange & Resource Network (IW: LEARN)	NGO	Global	Water	Deployment	The GEF IW:LEARN is a program that promotes experience sharing and learning among GEF International Waters projects and the country officials, agencies, and partners working on them. IWLEARN.NET supports knowledge sharing in the GEF IW portfolio and contains project-related information, contacts, documents, e.g. case studies, Transboundary Diagnostic Analyses, Strategic Action Programs, news and events. Outputs from GEF IW Conferences, guidance materials and products of GEF IW:LEARN or water-related learning are also available.
IPM Farmer Field Schools	NGO	Developing Countries	Agriculture	Deployment	The Farmer Field School is a form of adult education that evolved from the concept that farmers learn optimally from field observation and experimentation. Launched in Indonesia, it was developed to help farmers tailor their integrated pest management practices to diverse ecological conditions.
Knowledge for Tomorrow – Cooperative Research Projects in Sub-Saharan Africa	Public-Private Partnership	Germany, Africa	Land, Water, Biodiversity, Renewable Energy	Research	Knowledge for Tomorrow's overall intention is to provide junior scholars in Africa with opportunities to enhance their skills and academic qualifications, and thus to open up perspectives for the best of them to stay in academia. Besides the Afro-German cooperation, a second focus is on the development of academic networks in Africa
Lawrence Berkeley Institute for Globally Transformative Technologies (LIGTT)	NGO	U.S., South Asia, Sub-Saharan Africa	Health, Renewable Energy	Research, Development, Demonstration	The institute aims to create a pipeline for demand-driven technologies that match the Berkeley lab's technology capabilities in affordable, low-carbon technologies to fight global poverty. Its focus is on distributed technologies that will not need to rely on existing infrastructure. It expects to have 12 projects in pipeline at a given time.
Lighting Africa Imitative	NGO	Africa	Renewable Energy	Deployment	Lighting Africa is a joint IFC and World Bank program that is mobilizing the private sector to build sustainable markets to provide safe, affordable, and modern off-grid lighting to 2.5 million people in Africa by 2012 and to 250 million people by 2030. It aims to leverage global expenditures on fuel-based lighting to develop, accelerate and sustain the market for modern off-grid lighting alternatives including the latest light-emitting diode, fluorescent, human-cranking and solar technologies.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Man & the Biosphere Program	Government	Global	Climate Change, Biodiversity, Water, Natural Resource Management	Research	The MAB Program is an intergovernmental scientific program aiming to set a scientific basis for improving the relationship between people and their environment globally.
MekongInfo	NGO	Vietnam, Cambodia, Laos, Thailand	Natural Resource Management	Deployment	MekongInfo is a web-based system for sharing information and knowledge about participatory natural resource management in Cambodia, Laos, Thailand and Vietnam. It supports the Mekong River Commission Secretariat in its role as a regional networking and information dissemination body for lessons learned and promising approaches related to participatory natural resource management in the upper watershed.
Millennium Water Program (MWP)	NGO	Developing Countries	Water, Sanitation	Deployment	The MWPs are an initiative of the Millennium Water Alliance, a coalition of NGOs seeking to increase freshwater access and improve water and sanitation in the developing world. Two programs have been launched to date in Kenya and Ethiopia.
National Centers of Competence in Research (NCCR) North-South	NGO	Switzerland, Developing Countries	Sustainable Development, Global Change	Research	Encompassing a network of over 350 researchers active in more than 40 countries worldwide, the NCCR North-South is one of 20 National Centers of Competence in Research established by the Swiss National Science Foundation to promote scientific advancement in vital research areas in North-South research partnerships. Research is collaboratively conducted with a special emphasis on the needs of developing and transition countries, since they are arguably under the most pressure due to accelerated global processes of environmental, economic and socio-political change.
NER300	Government	EU	CCS, Biofuels, Concentrating Solar Power, Photovoltaics, Geothermal, Wind, Ocean, Hydropower	Demonstration	NER300 is an instrument offering grants to installations of innovative renewable energy projects, grid integration projects and up to 12 CCS projects for capturing and storing carbon dioxide from power generation using fossil fuels or primary industry. The grants will be obtained by selling up to 300 million carbon allowances (rights to emit one ton of CO_2) on the carbon market.
PLAC+E	NGO	Latin America	Renewable Energy, Energy Efficiency, Climate Change	Demonstration, Deployment	PLAC+E promotes the use of clean and alternative energies through the development and funding of innovative projects. It primarily facilitates carbon marketing.
Regional Institute for Science Education (RISE)	NGO	Sub-Saharan Africa	Various	Research	RISE prepares Ph.D. and M.Sc. level scientists and engineers in sub-Saharan Africa through university-based research and training networks in selected disciplines. Its primary emphases are on training new faculty to teach in African universities and on upgrading the qualifications of current faculty. The Science Research Group facilitates partnerships in the form of visits by senior faculty from outside of Africa to RISE network nodes, semesters at non-African universities for RISE network students, and international research collaborations.
Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)	NGO	Africa	Agriculture	Research	RUFORUM is a consortium of 29 universities in Eastern, Central and Southern Africa established in 2004. The consortium originally operated as a program of the Rockefeller Foundation from 1992. RUFORUM's mission is to strengthen the capacities of universities to foster innovations responsive to demands of small-holder farmers through the training of high quality researchers, the output of impact-oriented research, and the maintenance of collaborative working relations among researchers, farmers, national agricultural research institutions and governments.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Royal Botanic Gardens, Kew—Millennium Seedbank Project	Government	Global	Agriculture, Biodiversity	Research	Operated by the Royal Botanic Gardens, Kew, this is one of the largest international conservation projects undertaken to date. It aims to safeguard over 2,000 plant species worldwide against extinction and to secure the future of the UK's native flowering plants. The project also intends to carry out research to improve all aspects of seed conservation; make seeds available for research and species reintroduction into the wild; encourage plant conservation throughout the world by facilitating access to and transfer of seed conservation technology; maintain and promote the public interest in plant conservation; and provide a world-class facility as a focal resource for this activity.
S-REP (Scaling Renewable Energy Program)	NGO	Global	Renewable Energy	Demonstration, Deployment	Managed by the World Bank Strategic Climate Fund, S-REP will provide policy support and technical assistance to low-income countries and underwrite additional capital costs associated with renewable energy investments
Science and Technology Research Partnership for Sustainable Development (SATREPS)	Government	Japan, Developing Countries	Environment, Energy, Natural Disasters, Infectious Disease Control	Research, Development	SATREPS is a Japanese government program that promotes international joint research targeting global issues through three- to five-year projects involving partnerships between researchers in Japan and researchers in developing countries. SATREPS projects are expected to lead to outcomes with potential for practical utilization, and to enhance research capacity in the developing country. It appears that all projects are led by Japanese researchers. To date, 60 projects have been undertaken, at least 58 of them in a developing or emerging country.
Super Efficient Equipment and Appliance Demonstration Program (SEAD)	Government	Global	Energy Efficiency	Demonstration	SEAD will harness the market and convening power of Major Economies Forum countries to improve efficiency for appliances traded throughout the world. Coordinating incentives, standards and labeling systems can create unprecedented economies of scale for these appliances.
Solar and LED Access Program	Government	Developing Countries	Renewable Energy	Demonstration, Deployment	Solar and LED Access Program will accelerate demonstration of affordable solar home systems and LED lanterns to those without access to electricity.
South Africa-Norway Program on Research Cooperation	Government	South Africa, Norway	Climate Change, Environment, Health, Water, Education, Economic Development	Research	The research program is a bilateral initiative to promote research excellence and quality in joint research. The previous program ending in 2010 involved research teams from 15 Norwegian and 10 South African universities and research institutes. The current research program through 2013 focuses on environment and climate change.
Sustainable Agriculture Research for International Development (SARID)	Government	Africa, Asia	Agriculture	Research	The objective of this initiative is to promote biotechnology and biological sciences research that addresses the challenges to agriculture in developing countries—research that provides answers on how to increase agricultural productivity and food security so as to make significant differences to the lives of poor people in Africa and Asia. It is one of the new initiatives being implemented under DFID's £100 million Strategy for Research on Sustainable Agriculture
Sustainable Buildings Network (SBN)	Government	IEA Member Countries	Energy Efficiency	Research, Development, Demonstration, Deployment	The Sustainable Buildings Network was created in 2009 at the G-8 Summit in Italy. A collaboration between major economies, the SBN is a network of networks managed by the Renewable Energy and Energy Efficiency Partnership that aims to share information, identify gaps, and facilitate the implementation of best policy practices as well as the dissemination of existing material globally for both new and existing buildings. The four priority areas of work identified by SBN are zero energy buildings; intelligent tropical and hot climate architecture; energy efficiency in existing buildings; and building codes.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Sustainable Development Technology Canada (SDTC) Tech Fund	Government	Canada	Climate Change, Water, Soil	Demonstration, Development	SDTC targets proven technologies in lab-based environments that may have no other funding sources. 195 projects were financed as of end of 2010.
Sustainable Energy and Climate Change Initiative	Government	Latin America, Caribbean	Sustainability	Research, Development, Demonstration, Deployment	The goals of the Sustainable Energy and Climate Change Initiative are centered on the provision of comprehensive sustainability options in areas related to the energy, transportation, water and environmental sectors as well as building climate resilience in key priority areas vulnerable to the impacts of climate change. The initiative consists of four strategic pillars: energy, transportation, water and environment, climate resilience
Sustainable Energy for All	Public-Private Partnership	Global	Energy	Diffusion	A U.N. initiative that aims to ensure universal access to modern energy services; double the rate of improvement in energy efficiency; and double the share of renewable energy in the global energy mix. This group will bring together practitioners from the private sector and civil society working on the delivery of energy services and solutions related to electrification in a range of developing country contexts to develop a more integrated approach to energy access planning and execution.
SWASH +	NGO	Developing Countries	Water, Sanitation	Deployment	The SWASH+ projects in Kenya and Central America provide two different experiences of trying to design and implement school water, sanitation and hygiene (WASH) projects effectively and sustainably while studying the effects of school WASH, or its absence, on children. For its Kenya projects, SWASH+ has partnered with Emory University's Center for Global Safe Water to conduct randomized, controlled studies in 185 schools.
SysTem for Analysis, Research, and Training (START)	NGO	Africa, Asia-Pacific	Multiple	Research	START promotes research-driven capacity building to advance knowledge on global environmental change in Africa and Asia-Pacific. It does this through: research grants and fellowships, curricula development, advanced training institutes, multi-stakeholder dialogues, knowledge assessment and synthesis, and place-based strategic planning that build relevant capacities of both individuals and institutions for advancing education and research. START targets early/mid-career science professionals.
Technoserve	NGO	Developing Countries	Agriculture, Renewable Energy, Tourism	Deployment	Technoserve is an international NGO that aims to build capacity for enterprise in developing countries with the goal of transforming the lives of the rural poor by generating jobs and markets for their products and services. It provides field support to a range of public- and private-sector international development partnerships.
The Implementing Agreement for a Co-operative Program on Geothermal Energy Research and Technology (Geothermal IA)	Government	Global	Renewable Energy	Research, Development, Demonstration	Geothermal IA aims to raise awareness about geothermal technology, geothermal resource potentials, environmental and social benefits, and the lack of demonstration plants through collaborative RD&D. Current research projects include efforts to investigate advanced geothermal drilling techniques, the direct use of geothermal energy and enhanced geothermal systems.
The Implementing Agreement for a Co-operative Program on Hydropower Technologies and Programs (Hydropower IA)	Government	7 Countries	Renewable Energy	Research, Development	Hydropower IA aims to encourage through awareness, knowledge, and support the sustainable use of water resources for the development and management of hydropower.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
The Nature Conservancy (TNC)	NGO	Global	Climate Change, Agriculture, Health, Water, Forestry, Biodiversity	Research, Development, Demonstration, Deployment	TNC is an international conservation NGO that works both in the field, with communities and in policy circles to protect the conservation of ecosystems and species. The organization conducts basic and applied research, recommends conservation management strategies, and recommends policies to encourage conservation.
Tropical Agriculture Research & Higher Education Center (CATIE)	NGO	Latin America	Agriculture, Climate Change, Natural Resource Management	Research, Development, Demonstration, Deployment	CATIE is a regional scientific knowledge center for agriculture and the management of natural resources, dedicated to sustainable rural development and poverty reduction in tropical America. Its mission is to contribute to rural poverty reduction in tropical America by promoting competitive and sustainable agriculture and natural resource management through higher education, research and technical cooperation. Global change and especially climate change is one of CATIE's priority areas.
U.S. China Clean Energy Research Center (CERC)	Government	U.S., China	Climate Change, Renewable Energy, Energy Efficiency	Research, Development	CERC's joint R&D work plans have been assigned in three areas: building efficiency, advanced coal, and clean vehicles.
U.S. Department of Energy New Model Licensing Agreements	Government	U.S.	Energy Efficiency, Renewable Energy	Diffusion	The Department of Energy will offer a license to nonprofit organizations with a demonstrated commitment to providing global access to clean technologies and services. Licensees will pay a reduced fee and a nominal royalty. These organizations will have access to the unlicensed patents held at department headquarters for clean energy technologies.
U.S. Water Partnership	Public-Private Partnership	Global	Water	Deployment	Its mission is to unite and mobilize the "best of U.S." expertise, resources and ingenuity to address water challenges around the globe, with a special focus on developing countries where needs are greatest.
U.S.-Australia Clean Energy Solutions Center	Government	Global	Renewable Energy	Research, Development, Demonstration, Deployment	It is a virtual clearinghouse of clean energy policies and programs to help policymakers design and adopt clean energy programs
UNDP Global Environment Facility	Government	Global	Various	Research, Development, Demonstration, Deployment	UNDP-GEF offers countries highly specialized technical services for eligibly assessment, program/project formulation, due diligence, mobilization of required co-financing, project implementation oversight, results management and evaluation, performance-based payments and knowledge management.
UNESCO University—Industry Partnerships (UNISPAR)	Government	Global	Various	Research	UNESCO's UNISPAR program was launched in 1993 to improve the quality of universities in developing countries and encourage them to become more involved in the process of industrialization of their country. Current projects include: creating innovation hubs at Arab universities, and creating science and technology parks.
UNFCCC Technology Mechanism	Government	Global	Climate Change	Demonstration, Deployment	IThe UNFCCC Technology Mechanism consists of a Technology Executive Committee with a mandate to conduct needed analysis; recommend policy actions; guide development of low emissions development strategies; facilitate collaboration for tech transfer, It also consists of a Climate Technology Center Network which aims to facilitate networking and information provision.
USAID EcoLinks	Government	U.S., Central Europe, Eastern Europe, Asia	Urban Environmental Problems, Industrial Environmental Problems		This initiative that promotes market-based solutions to urban and industrial environmental problems in Central and Eastern Europe and Eurasia. The program creates partnerships among businesses, local governments and associations in the region, and between these organizations and their counterparts in the United States. It has two programs: the Partnership Grants Program and the Trade and Investment Program. The primary responsibility of the Grants Program is to provide financial assistance for initial partner meetings and for feasibility studies; the Trade and Investment component facilitates the transfer of environmental technology.

Program	Organization type	Target region / countries	Sectors covered	Technology phase	Description
Water Efficient Maize for Africa (WEMA)	Public-Private Partnership	Africa	Agriculture, Water	Research, Development, Demonstration, Deployment	WEMA seeks to develop drought-tolerant maize varieties to benefit smallholder African farmers in five countries. It aims to do this through conventional breeding, marker-assisted breeding and biotechnology. Efforts are being undertaken in Kenya, Mozambique, South Africa, Tanzania and Uganda.
Water for People	NGO	Developing Countries	Water	Deployment	Water for People is an international nonprofit that supports the development of locally sustainable drinking water resources, sanitation facilities and hygiene education programs. It currently works in 11 developing countries in Africa, Latin America and the Indian subcontinent.
Wind Energy Technology Platform (TPWind)	Government	EU	Renewable Energy	Research, Development, Demonstration	The objective of TPWind is to identify areas for increased innovation, new and existing research and development tasks, coordinate R&D and analyze the market. It is composed of five working groups, an advisory board, and a steering committee with stakeholders from industry, government, civil society, R&D Institutions, finance organizations and the wider power sector. The organization has written an EU wind market strategy through the year 2030, which includes both an R&D agenda and a demonstration strategy.
WIPO Green: The Sustainable Technology Marketplace	NGO	Global	Climate Change, Waste Eeduction, Alternative Energy, Energy Efficiency	Research, Development, Demonstration, Deployment	WIPO Green is a sustainable technology marketplace whose objectives are the "accelerated adaptation, adoption, and development of environmental technologies." The initiative was created with industry, particularly the Japan Intellectual Property Association. One of the unique features of WIPO Green is that information on technology will be made accessible, including know how, associated services and the materials needed to implement the technology. In addition, basic licensing tools will also be available on the database.
World Agroforestry Center (ICRAF)	NGO	Global	Agroforestry	Research, Development, Demonstration, Deployment	ICRAF is an international NGO that conducts agro-forestry research for environmental protection and poverty alleviation. It joined the CGIAR in 1991. In addition to conducting scientific and policy research, ICRAF has an award fellowship program, and a professional development program that strengthens the research and leadership skills of African women in agricultural science.
World Bank Climate Innovation Centers	NGO	Developing Countries	Climate Change	Demonstration, Deployment	The Climate Innovation Centers (CICs) will be a network of physical incubation centers to accelerate the development, deployment, and transfer of locally relevant climate technologies. The CICs boost developing country Green Growth and job creation by financing and supporting the competitive and profitable involvement of clean tech small and medium enterprises in local and international supply-chains and markets. The first one is set to open in Kenya in summer 2012
World Conservation Union (IUCN)	NGO	Developing Countries	Biodiversity	Research, Development	The IUCN performs many research, coordination, management, and policy services related to biodiversity, including: bioprospecting, assessment of impact of access activity on biodiversity, inventories and case studies of access and benefit sharing measures, development of relevant measures on ABS and traditional knowledge information management and exchange, public education and awareness, human resource development, capacity building of indigenous and local communities, institutional capacity building
World Intellectual Property Organization (WIPO)	NGO	Global	Various	Research, Development, Demonstration, Deployment	WIPO is the United Nations agency dedicated to the use of intellectual property (patents, copyright, trademarks, designs, etc.) as a means of stimulating innovation and creativity. WIPO operates several programs focused on technology transfer and green technology, including WIPO Green, Technology Innovation & Support Centers, training programs for capacity building, and WIPO Academy for distance learning.
World Wildlife Fund (WWF)	NGO	Global	Biodiversity, Climate Change	Research, Development, Demonstration, Deployment	WWF's mission is to conserve nature and reduce the most pressing threats to the diversity of life on Earth. It works in 100 countries with hundreds of partners to protect endangered ecosystems and species through science-based management solutions.

Source: Organization websites, news articles, industry reports. Some description information has been used verbatim from organization websites and past industry reports.

BIBLIOGRAPHY

Batelle and R&D Magazine. (2010). *2011 Global R&D Funding Forecast*. December 2010.

Bloomberg New Energy Finance (BNEF) and the United Nations Environment Programme (UNEP). (2012). *Global Trends in Renewable Energy Investment 2012*.

Dutz, Mark and Siddarth Sharma. (2012). *Green Growth, Technology & Innovation*. World Bank Policy Research Working Paper 5932

European Bank for Reconstruction and Development (EBRD). (2011). *How to Overcome Barriers to Green Growth in Emerging Economies*. Presentation by Jaakko Henttonen, NDEP Manager at EBRD, at the 11th European Forum on Eco-innovation, Lahti 12 October 2011.

Global Intellectual Property Center. Year Unknown. *Prizes and Patent Pools: Viable Alternatives to the Patent System?* GIPC White Paper Series

Kerr, Thomas. (2010). *Global Gaps in Clean Energy RD&D: Update and Recommendations for International Collaboration*. International Energy Agency report for the Clean Energy Ministerial.

Hammond, Allen and William J. Kramer, Julia Tran, Rob Katz. (2007). *The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid*. International Finance Corporation (IFC) and World Resources Institute (WRI).

International Energy Agency. (2010). Energy Technology Initiatives: Implementation through Multilateral Cooperation.

Morales, Alex. (2012). "Renewable energy investment in quarter plunges to three year low." *Bloomberg BusinessWeek*, April 12, 2012.

Morey, Jessica, Lewis Milford, Lindsay Madeira, and Valerie Stori. (2011). *Moving Climate Innovation into the 21st Century: emerging lessons from other sectors and options for a new climate innovation initiative*. Report by the Clean Energy Group for the UK Department for International Development and Department of Energy and Climate Change, May 2011.

Ockwell, D. et al. (2010), "Enhancing Developing Country Access to Eco-Innovation: The Case of Technology Transfer and Climate Change in a Post-2012 Policy Framework", *OECD Environment Working Papers*, No. 12, OECD Publishing.

Organization for Economic Cooperation and Development (OECD). (2011). Global Science Forum. *Opportunities, Challenges and Good Practices in International Research Cooperation between Developed and Developing Countries.*

Prahalad, C.K. and, Allen Hammond. (2002). Serving the world's poor, profitably. Harvard Business Review. 80(9):48-58.

Rangan, V. Kasturi and John A. Quelch, Gustavo Herrero, and Brooke Barton, eds. (2007). Business Solutions for the Global Poor: Creating Social and Economic Value.

Rosenberg, Tina. (2011). "A Pay for Performance Evolution." *New York Times,* March 17, 2011.

Sierra, Katherine. (2011). *The Green Climate Fund: Options for Mobilizing the Private Sector.* Brookings Institution.

United Nations (2011). *World Economic and Social Survey 2011: The Great Green Technological Transformation*. United Nations Department of Economic and Social Affairs (UNDESA). New York, 2011.

United Nations Development Program (UNDP). (2012). *Public Private Partnerships: Case Studies for Sustainable Development*. South South Cooperation Unit.

United Nations Education, Scientific & Cultural Organization (UNESCO). (2010). *UNESCO Science Report 2010: The Current Status of Science Around the World*. UNESCO Publishing.

United Nations Environment Programme (UNEP). (2012). *Measuring Progress Towards a Green Economy: draft working paper*. UNEP, June 2012.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2010). *UNESCO Science Report 2010: the current status of science around the world*. UNESCO Publishing.

United States Patent and Trademark Office. (2009). *Pilot Program for Green Technologies Including Greenhouse Gas Reduction*. Notice for applications, docket No. PTO-P-2009-0038, Department of Commerce.

World Bank. (2011). "Creating a Network of Climate Innovation Centers" (flyer).

World Economic Forum and Boston Consulting Group. (2011). *Redefining the Future of Growth: The New Sustainability Champions*.

World Intellectual Property Organization (WIPO). (2011). *World Intellectual Property Report* 2011: The Changing Face of Innovation.

World Resources Institute (WRI). (2011). *A Compilation of Green Economy Policies, Programs, and Initiatives from Around the World*. The Green Economy in Practice: Interactive Workshop 1. February 11, 2011.

ENDNOTES

1. International Energy Agency. (2011). Energy for All: Financing Access for the Poor
2. United Nations Water Programme. (2012). UN Water Statistics: Drinking Water and Sanitation
3. Hammond, Allen; William Kramer; Julia Tran; Rob Katz et al. (2007). The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid
4. For more information on this topic please see the following resources: World Bank (2012) Dutz, Mark and Sharma, Siddarth, *Green Growth, Technology & Innovation.* Policy Research Working Paper 5932; World Bank (2012) *Inclusive Green Growth The Pathway to Sustainable Development.* Washington: The World Bank; World Economic and Social Survey 2011, *The Great Green Technological Transformation,* The United Nations: New York; Tomlinson, Shane, Zorlu, Pelin and Langley, Claire (2008) E3G report launch: Innovation and Technology Transfer: Framework for a Global Climate Deal; Xiaomei Tan and Zhao Gang. "An Emerging Revolution: Clean Technology Research, Development and Innovation in China." WRI Working Paper. World Resources Institute, Washington DC.; Sauter, Raphael and Jim Watson, (2008) *Technology Leapfrogging: A Review of the Evidence,* Sussex Energy Group, University of Sussex, 2008; IEA (2010) *Energy Technology Roadmaps: a guide to implementation,* IEA: Paris; Dechezleprêtre, Antoine, Matthieu Glachant, Ivan Hascic, Nick Johnstone, and Yann Ménière. (2011) *Invention and transfer of climate mitigation technologies on a global scale: a study drawing on patent data.*
5. Social equity in connection with green growth is defined by the United Nations Environment Programme (UNEP) as an overall measure of human and social development, including dimensions such as poverty alleviation, equity, social inclusiveness, overall well-being and inclusive wealth. In terms of green growth, social equity includes indicators such as growth in employment, growth of the environmental goods and services sector, total wealth including human capital, natural capital, and produced capital, and access to key resources such as clean energy, water and sanitation, and health.
6. For more information on green growth, see the following studies: Dutz et al. (2012). Green Growth, Technology & Innovation. World Bank Policy Research Working Paper; OECD (2011) *Towards Green Growth;* UNEP (2011) *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication.* World Bank (2012) *Inclusive Green Growth: The Pathway to Sustainable Development.*
7. Prahalad and Hammond (2002).
8. Dutz (2012), p.12.
9. Batelle, R&D Magazine (2011). "2012 Global R&D Funding Forecast." December 2011,. All figures measured in Purchasing Power Parity (PPP) terms.
10. Developed countries defined as all countries with GBP per capital at the levels of Western Europe. Excludes Eastern Europe
11. BNEF, UNEP (2012)
12. ibid
13. World Economic Forum and Boston Consulting Group. (2011). *Redefining the Future of Growth: The New Sustainability Champions,.*
14. Mark Dutz and Siddarth Sharma (2012),
15. The United States Patent and Trademark Office (USPTO), in relation to their Green Technology Pilot Program, defines green patents and greenhouse gas reducing technologies as applications pertaining to environmental quality, energy conservation, development of renewable energy resources or greenhouse gas emission reduction.
16. Mark Dutz and Siddarth Sharma (2012), p.6.
17. Dutz and Sharma (2012).
18. UNESCO. (2010). Science Report.
19. Dutz, 2011, p.9
20. Based on a comparison of various estimates of renewable energy, energy efficiency, and smart grid R&D spending versus estimates of total global R&D spending

21. Tom Kerr (2010). *Global Gaps in Clean Energy RD&D: Update and Recommendations for International Collaboration*. International Energy Agency report for the Clean Energy Ministerial.
22. BNEF, UNEP (2012),
23. UNESCO. (2010). Science Report.
24. Mark Dutz and Siddarth Sharma (2012), p.36
25. Mark Dutz and Siddarth Sharma (2012)
26. BNEF, UNEP (2010)
27. BNEF, UNEP (2012),
28. Vijay Govindarajan and Chris Trimble. (2010). Reverse Innovation: Create Far from Home, Win Everywhere.
29. BNEF, UNEP (2012)
30. International Financial Statistics of the IMF
31. BNEF, UNEP (2012),
32. A public-private partnership is a venture that is funded and operated by a governmental or NGO organization and at least one private sector company in order to achieve a social purpose. In some cases, the partnerships are jointly funded and operated by both the public and private entities, and in other cases the funding is provided by one type of organization while the operations are carried out by another.
33. Because of the scope of this research project, purely private sector initiatives are not covered. This is an area for future research.
34. UNDP Special Unit for South South Collaboration (2012) http://www.ncppp.org/undp/index.html
35. IEA (2010). *Energy Technology Initiatives: Implementation through Multilateral Cooperation*
36. Overseas Development Assistance funding is focused on sub-Saharan Africa (44 percent of funding); Asia (30 percent); Middle East and North Africa (10 percent) Eastern Europe (6 percent) and Latin American and the Caribbean (10 percent). Source: OECD DAC: Table 28. Regional Distribution of ODA by Individual DAC Donors http://www.oecd.org/document/0,3746,en_2649_201185_46462759_1_1_1_1,00.html
37. Some agricultural initiatives may also target water. For example, one of the CGIAR centers focuses on water policy.
38. Two CGIAR centers focus on forestry.
39. Select sources: BNEF and UNEP. (2011). Global Trends in Renewable Energy Investment; IEA. (2010). Global Gaps in Clean Technology RD&D. Dutz and Sharma (2012). Green Growth, Technology & Innovation; Clean Energy Group (2010). Accelerating Climate Technologies.
40. It is beyond the scope of this paper to quantify the required international funding for green growth innovation, but even lifting LDCs current levels of innovation activity to those of the emerging innovator countries would imply billions of dollars in incremental annual investment

BROOKINGS

1775 Massachusetts Avenue, NW
Washington, DC 20036
202.797.6000
www.brookings.edu/global