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POLICYANALYSISBRIEF

THE STANLEY FOUNDATION | APRIL 2016

Technology Development and Transfer for a Safe Climate Future

Key Findings

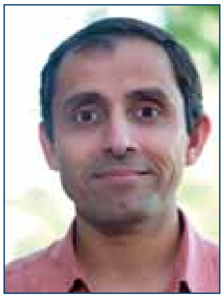
Enhanced international cooperation on technology development and transfer should create win-win outcomes through a range of activities, such as increased support for:

- Developing countries to help develop climate technology action plans and implementation pathways that take into account developmental challenges and aspirations of these countries.
- Technology development, finance, business-model development, and policy design to fill the gaps in various stages of the technology cycle for the technologies being deployed in developing countries.
- Broader activities such as synthesis of best practices for technology deployment, South-South experience sharing, and capacity building.
- Development of joint research-and-development (R&D) facilities and technology clubs that could enhance the technology innovation process to address climate change.

Technology is seen as a key means of implementation for developing countries to address their climate (and other sustainable development) challenges. Hence, the issue of technology development and transfer receives much attention in the climate arena. This policy brief discusses some of the key issues surrounding technology in the climate arena, with particular attention to developing countries. Specifically, it suggests a number of actions that could be taken domestically within industrialized and developing countries to strengthen technology development and transfer as well as through international cooperation.

The Twin Challenges of Climate and Development

Given the complexities of climate and developmental challenges, and the limitations of space, we will examine these issues only through the lens of energy. While this provides a limited perspective, the significant linkages between the energy sector and greenhouse-gas emissions, as well as with human and economic development, still allow us a reasonable perspective into the kinds of issues that need to be resolved and addressed if developing countries are to meet their developmental and climate challenges.

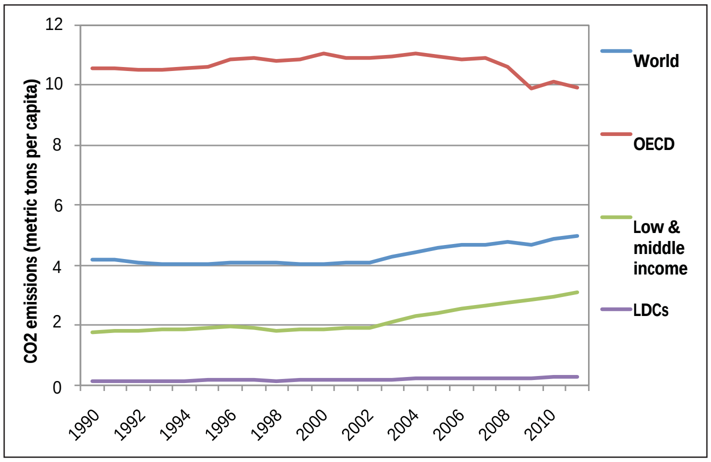


Ambuj Sager

Author

Ambuj Sager is the Vipula and Mahesh Chaturvedi Professor of Policy Studies at the Indian Institute of Technology Delhi. Professor Sagar's interests broadly center on the interactions between science, technology, and development, with a particular focus at present on leveraging innovation to meet environment and development challenges. His recent papers have dealt with energy innovation policy and strategies (in areas such as clean cooking energy, coal power, and biofuels and institutional mechanisms such as climate innovation centers), climate change policy and politics, and capacity development. He has served as consultant/adviser to various Indian government ministries as well as many multilateral and bilateral agencies.

While most developing countries have low per-capita carbon emissions[1] (see Figure 1a comparing the world, countries in the Organisation for Economic Co-operation and Development [OECD], low- and middle-income countries, and least-developed countries [LDCs]), these emissions are likely to rise in the future as the level of economic activity, and concomitantly, standards of living, rise. Notably, many developing economies have carbon intensities (i.e., carbon emissions per unit of gross domestic product [GDP]) that are higher than the world average, which can be attributed to the dominance of fossil fuels in their energy mix and the high energy intensity (i.e., energy use per unit of GDP, which is a measure of the energy efficiency of the economy), although many of the poorer developing countries have very low carbon intensities due to dependence on biomass as a major energy source (see Figure 1b).



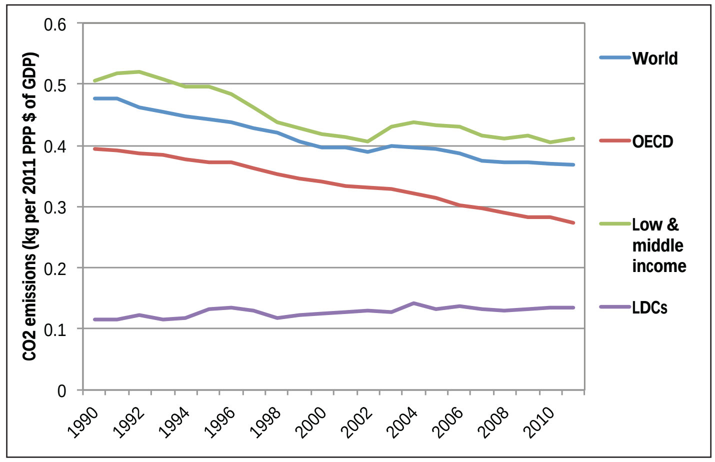


Figure 1a (left): CO2 emissions per capita. Figure 1b: CO2 intensity of GDP. (Source: World Bank World Development Indicators datasets)

At the same time, developing countries have pressing developmental imperatives that need to be addressed even as they grapple with the twin climate challenges of mitigation and adaptation.

Developing countries generally have far lower energy availability and use per capita than the global average. This is important, since, as noted above, energy use is intimately interlinked to economic and human development. Figure 2 shows the energy and electricity use per capita across various country groups.

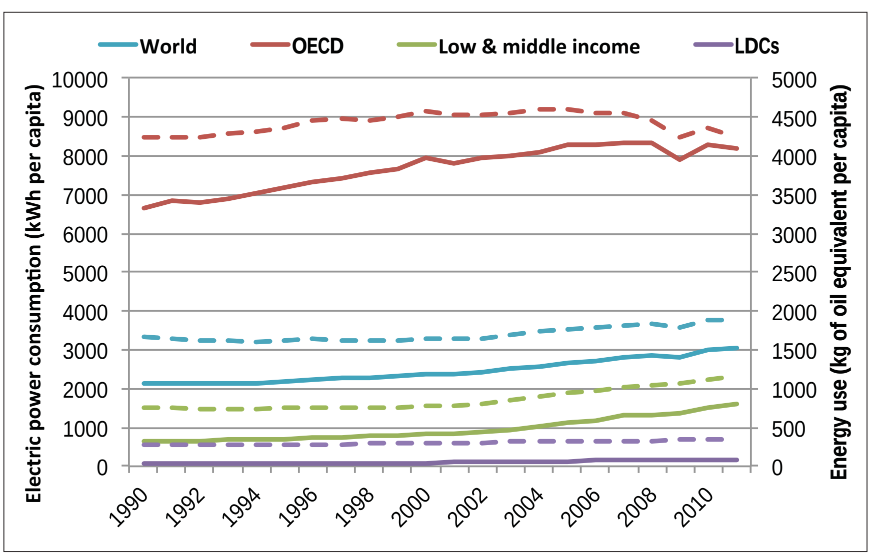


Figure 2: Per-capita annual electricity (solid lines) and energy use (dashed lines) in key regions. (Source: World Bank World Development Indicators datasets)

Electricity use is particularly useful as an indicator to modern clean energy services, given its ability to deliver a wide range of services such as lighting, heating/cooling, cooking, and mechanical power. Obviously, developing countries need to significantly expand their energy supplies. Furthermore, there are substantial numbers of people worldwide who still do not have any access to clean and modern forms of energy (see Table 1). Projections indicate that while the situation will be somewhat ameliorated by 2030 under business as usual (at least for electricity access), the numbers will still be large enough to be a cause of concern. Therefore, access and affordability become additional key requirements.

Thus developing countries can be seen as having two major sets of developmental challenges: to promote economic and human development across the board to raise the standards of living for their citizens, and to particularly uplift the poorest and the most marginalized in their countries and bring them into modernity and ensure at least a minimum basic standard of living (and access to basic needs such as energy, food, and water).

	Population without electricity (millions)		Population relying on traditional use of biomass (millions)	
	2011	2030	2011	2030
WORLD	1,285	969	2,679	2,524
Africa	622	645	728	881
Sub-Saharan Africa	621	645	1	879
Developing Asia	620	324	1,875	1,582
China	3	0	448	241
India	304	146	815	730

Table 1: Current status and projected trends in energy access. (Sources: International Energy Agency [IEA] World Energy Outlook 2014 and IEA energy access database)

These developmental and climate challenges have to be met simultaneously since no developing country can afford to (or should) ignore its developmental imperatives to address climate change, and addressing only development imperatives is equally problematic since it will lock in climate-incompatible infrastructure and development patterns, thereby contributing to climate change, which will reverse many developmental gains.

Capabilities and Resources for Climate Innovation

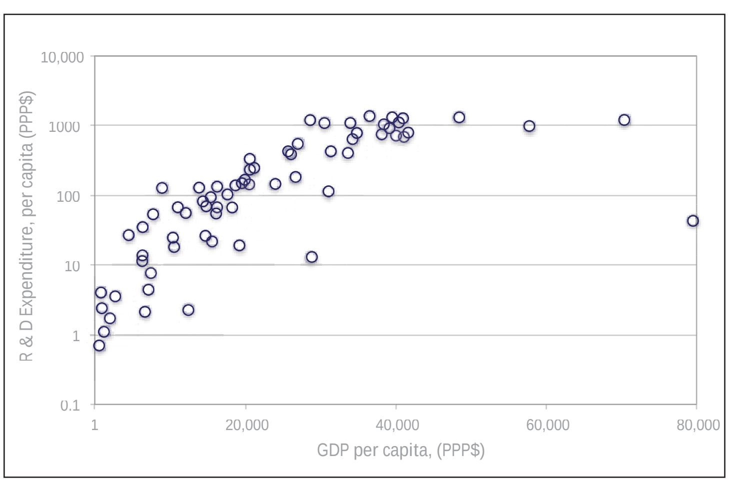
Given the magnitude of the climate and developmental challenges facing developing countries, how might these countries be best assisted in managing the requisite technological transition? The answer to this question requires some understanding of the capabilities and resources required for successful climate innovation and of their current landscape.

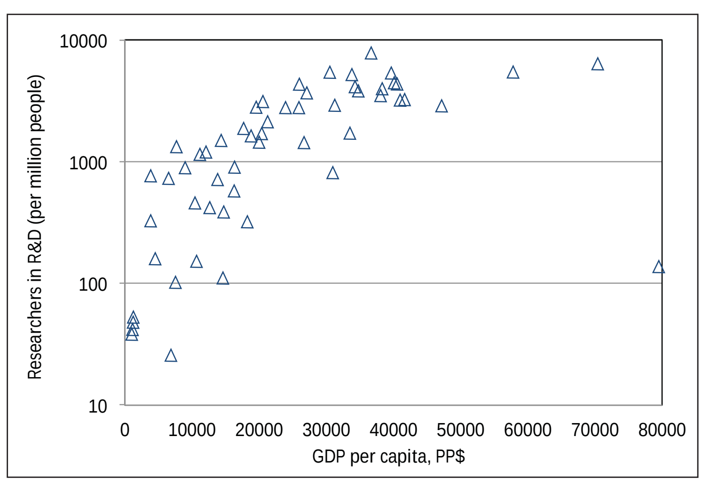
A Macro Perspective

Looking at standard indicators of the scale of the science, technology, and innovation (STI) enterprise such as gross expenditure on R&D or the number of researchers per million inhabitants (Figures 3a and 3b), one sees that poorer countries generally invest far less in STI that their richer counterparts (because their per-capita GDP is much lower and they also invest lower fractions of their GDP) and also have a smaller stock of technically skilled personnel. Cross-country composite measures of innovation, which take into account multiple dimensions of innovation inputs and outputs, such as the Global Innovation Index (copublished by the World Intellectual Property Organization, Cornell University and the graduate business school INSEAD), also reflect the same trends, that is, the poorer countries have lower innovation capabilities and outputs.

They also do not have the financial resources needed to engage in the required deep technological transition. According to recent estimates by the International Energy Agency (IEA), a transition to low-carbon systems to stay well below a

Figure 3a (lower left): Gross R&D investments per capita; Figure 3b: Researchers engaged in R&D (per million population); both figures are in terms of purchasing power parity. (Sources: United Nations Educational, Scientific and Cultural Organization Institute for Statistics and World Bank World Development Indicators datasets)





2° C global average temperature increase will require additional investments of as much as $40 trillion between 2016 and 2050. Most of these investments will be required in non-OECD economies since these countries are expected to account for much of the additions to the energy system over this period to satisfy their development needs.[2] This further highlights the magnitude of the challenge facing developing countries.

While the richer, industrialized countries do invest significantly in innovation, there are two aspects that are germane to investments in climate innovation.

First, climate change is a global commons problem, so investments by any one country in addressing climate change spreads the environmental benefits globally and not just in that country (and conversely, investments by other countries help address climate change regardless of a given country's investments, potentially leading to a free-rider problem).[3] Therefore, countries tend to invest less in climate innovation than what is estimated to be required to avoid dangerous climate change. In fact, trends in the public energy research development and demonstration (ERD&D) investments by member countries of the International Environment Agency arguably demonstrate this. Figure 4 shows that these expenditures have risen only recently, even though by 1992 there was agreement on the importance of addressing climate problem, as manifested in the ratification of the United Nations Framework Convention on Climate Change by all countries. It is also notable that current levels of public ERD&D investments by IEA countries are still lower than the peak levels reached after the oil crisis of the 1970s. Consequently, there have been suggestions that investments on energy innovation need to rise significantly.[4]

Second, private actors are responsible for the dominant portion of STI investments in industrialized countries. These actors really are the key players in translating knowledge into commercial application, and therefore their investment decisions shape the emergence of new technologies, products, and services. But the private sector underinvests in areas that have a public goods nature since they are not able to appropriate the full benefits of such technological advances, even though they might have a significant social benefit. Therefore, while a cleaner environment may benefit everyone, the value of this cleaner environment may not be fully apparent, and even to the extent it is, again, it often is not fully incorporated into the price of goods and services, especially in the absence of clear and strong policy signals.

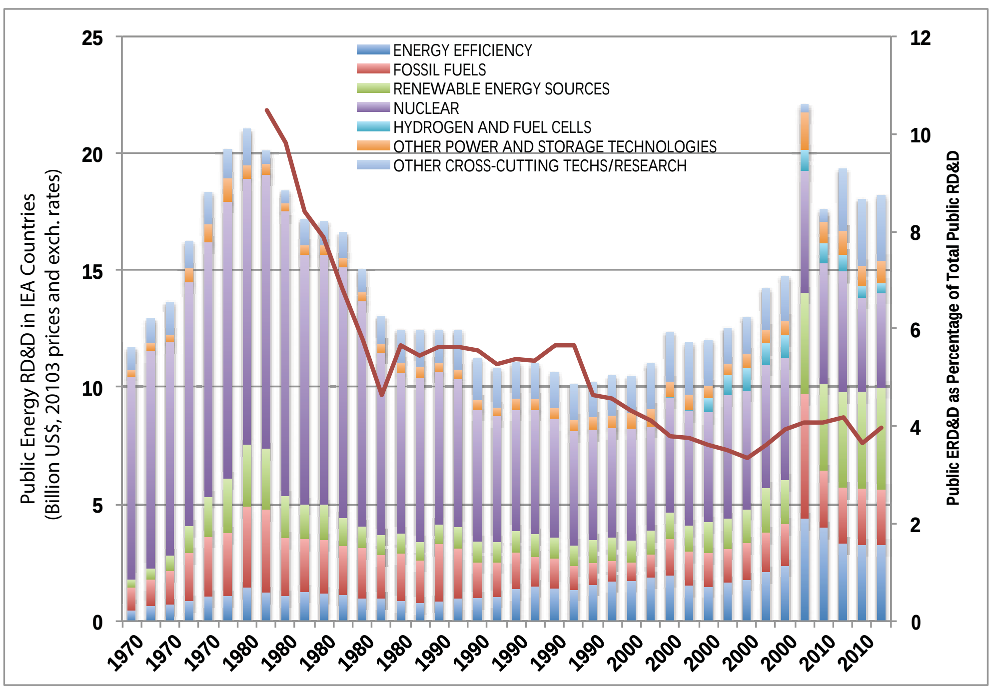


Figure 4: Trends in public ERD&D investments by IEA member countries (Sources: IEA ERD&D database and OECD Statistics)

Still, in the case of renewable energy, for example, there have been significant investments by the private sector in developing and deploying new technologies, driven in large part by growing markets for these technologies in various parts of the world. But there have been fluctuations in these investments (see, for example, Figure 5) due to, among other reasons, lack of a consistent long-term signal as well as movements in prices of fossil fuels

A Micro Perspective

A stylized depiction of the innovation process is presented in Figure 6. There are a few points to note here:

The nature of the activities changes as one proceeds along the stages of the technology cycle, from the upstream side (research and technology development) to the downstream side (commercialization and deployment). Concomitantly, the nature and scale of the required resources (technical, financial, human, organizational, and institutional) also change by stage.[5] For example, the upstream part is more exploratory in nature, thereby requiring researchers and higher-risk capital providers, whereas in the downstream part, the focus is on product development, manufacturing, and deployment with an emphasis on design and engineering and the need for (lower-risk) asset financing providers.

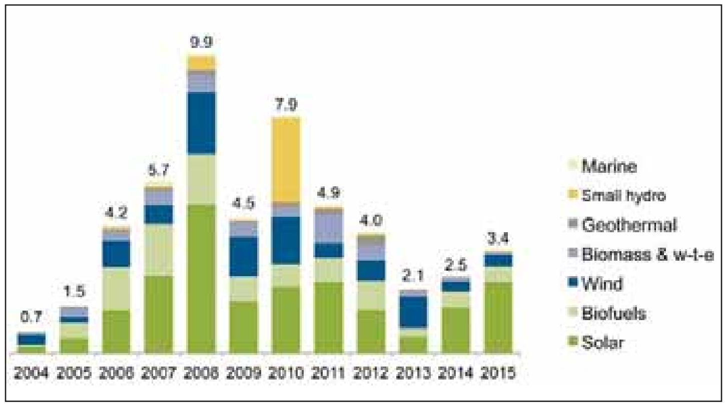


Figure 5: Trends in venture-capital and private-equity investments in renewable energy (w-t-e = waste to energy).

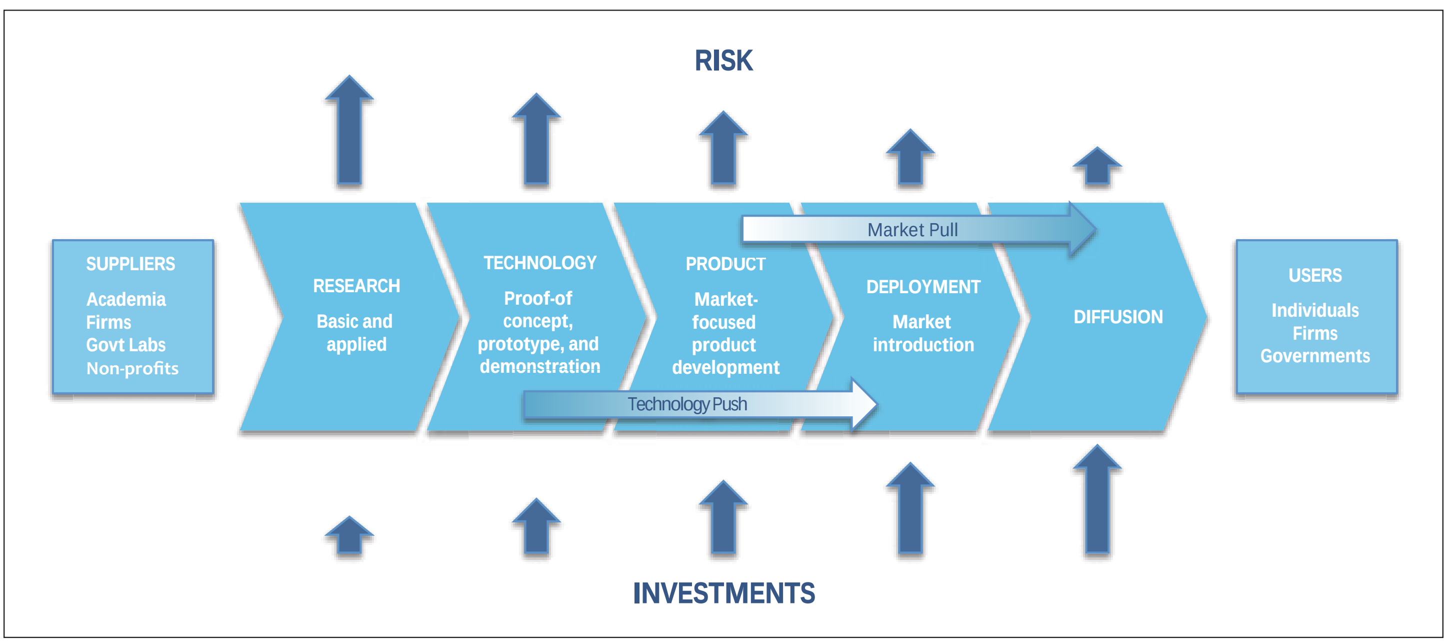
(Sources: Frankfurt School-United Nations Environment Programme Centre/ Bloomberg New Energy Finance, *Global Trends in Renewable Energy Investment 2015*)

The resource requirements vary from technology to technology (i.e., different technologies will have different requirements at any particular stage). Similarly, the resources for taking forward any particular technology required vary from country to country (and sometimes even region to region). For example, the implementation of wind energy may require different technologies, different actors, and different policies to support the deployment across different contexts.

Not surprisingly, then, the capabilities and resources requirements—and the gaps—are specific to technologies and the national/local contexts.

Broadly, it could be said that the three key stages for the introduction and deployment of a new technology are the initial adoption stage, where the technology is adapted for local use conditions and its utility and feasibility demonstrated; the market creation stage, where the technology begins to get traction with a wider body of users locally; and the deployment stage, where the focus is on ensuring that there is a large-scale uptake by users. Each of these stages needs attention to ensure successful deployment of climate technologies at scale.

Figure 6 (below) A stylized depiction of the innovation process.



The Way Forward

With this backdrop, three sets of actions are germane to advancing the availability and implementation of climate technologies in developing countries. The first two pertain to domestic actions within industrialized and developing economies and the third to international cooperation on climate technology development and transfer.

1. Given that a dominant fraction of innovation capabilities are in industrialized economies, these countries will have to take the lead in developing and deploying technologies required to advance climate mitigation and adaptation so as to enhance the availability of, and cost-reductions in, these technologies. This will require greater investments in climate innovation on their part.

2. Developing countries also need to invest in building their own capabilities to adapt technologies to the local use context and to deploy them. Most important among these is the capability to prioritize from among their climate and development needs,[6] to develop a strategic plan that allows them to balance various needs,[7] to coordinate various actors involved in implementing such pathways, and to identify and help fill specific gaps. Such strategic and coordination capability is particularly key in managing the climate technology transition in developing countries.

3. International cooperation to assist in making available and deploying climate technologies in developing countries needs to take an approach that is cognizant of the requirements of the technology cycle. This requires identification of the specific innovation gaps for any technology that is to be deployed in a particular country and to marshal resources specifically to fill these gaps.

The three key stages for the introduction and deployment of a new technology are:
1) Initial adoption
2) Market creation
3) Deployment

These sets of actions could include supporting activities at the national level specific to countries, such as:

- Assist in the formulation and implementation of a strategic climate technology plan that takes into account the developmental needs and aspirations of the country as well as its resources and capabilities.

- Provide appropriate technical support, especially for early stages of the technology cycle where technologies might need to be modified for local use conditions, development of demonstration projects, and further refinement on the basis of user feedback.

- Ensure appropriate finance is available for various stages of the technology cycle. This may require different actors engaging with different parts of the cycle. For example, philanthropic organizations may be able to support early-stage, riskier activities whereas traditional donor organizations could cover later-stage activities such as those facilitating market creation, say, through support for demonstration projects or other risk-mitigation instruments.

- Assist in delivery-model and policy design to facilitate deployment at scale.

In addition, some activities could be of value across countries, such as:

- Developing and sharing a synthesis of experiences with, and lessons from, delivery models for scaling up deployment of climate technologies.

- Compiling a list of policies and instruments to support market creation and large-scale deployment and experiences with these in different countries.

- Facilitating South-South networks to share experience more broadly and to develop synergies.
- Human and institutional capacity building to help better support the technology transition activities in developing countries.

Lastly, it might be possible to consider setting up new global programs such as:

- A joint R&D facility that could focus specifically on addressing technology issues for developing countries, including the development of new technologies that might not be developed by the existing technology players due to limited markets.
- Technology clubs that bring together key industrialized and developing countries to enhance their individual and joint efforts on technology development and deployment, supported by policy instruments that facilitate such activities as well as maximize their benefits.

Endnotes

1 In some cases, though, their large populations may cause them to be large aggregate emitters, such as India and Indonesia.

2 International Energy Agency (IEA), *Energy Technology Perspectives 2015* (Paris: IEA, OECD, 2015).

3 To make matters worse, the costs of not addressing climate change are likely to be disproportionately borne by developing countries, which can give industrialized countries even less motivation to invest in mitigating this problem.

4 International Energy Agency (IEA), *Energy Technology Perspectives 2015* (Paris: IEA, OECD, 2015); American Energy Innovation Council, (AEIC) Restoring American Energy Innovation Leadership: Report Card, Challenges, and Opportunities—2015, AEIC: Washington, DC (2015).

5 The term *institutional* is used in the sense of the rules of the game that are characteristics of the social, political, and cultural context—examples being policies and laws, culture, and norms—in which the innovation process is embedded.

6 See, for example, A. Chaudhary, A.D. Sagar, and A. Mathur, "Innovating for Energy Efficiency: A Perspective from India," *Innovation and Development*, Vol. 2, No. 1 (2012), pp. 45–66.

7 For example, different deployment pathways for solar energy may give different weights to energy access, climate mitigation, and industrial development.

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THE STANLEY FOUNDATION | 209 IOWA AVENUE, MUSCATINE, IA 52761 USA
563-264-1500 | 563-264-0864 FAX | INFO@STANLEYFOUNDATION.ORG