Innovation for climate-compatible development for the 'bottom of the pyramid'

Policy brief

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Abstract

Essentially, significant parts of the world's population continue to lack access to modern and clean forms of energy, with concomitant human, social, and economic costs for this group. While technology is often seen as key to addressing this challenge, translating this potential contribution into reality is complicated by the complexity of the problem and the relative paucity of the available resources.

This policy brief will discuss how to organize and advance technological innovation – and key aspects of innovation policies – to contribute to climate-compatible development for the 'bottom of the pyramid,' drawing on lessons and experiences from the literature as well as two specific application areas, household energy and rural electricity. Basically, deployment of suitable technologies at large scale requires that close attention be paid to technology development/adaptation to ensure that the resulting technologies and products seen by users as offering useful services and at a price point that they (or the agencies supporting the deployment of these technologies) can afford. Innovative models, such as innovation prizes or advanced market commitments, may complement traditional 'R&D' push approaches to the development of such technology.

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Furthermore, deployment models also will need to be designed taking into account the user characteristics and the local institutional context; again, innovations in these models are needed for successful large-scale deployment. A strategic approach to technology development and deployment – focusing initially on market/user segments most conducive to success – is important in both developing markets for, as well as consumer confidence in, these technologies

Coordination of various actors and activities that constitute the innovation process, as well as learning from historical experiences and other ongoing programmes, are also important. But more than anything else, the long-term success of any effort hinges on the development of local human and institutional capabilities to organize and execute this innovation process. Lastly, additional finance - necessary to support these energy-access-enhancing activities – needs to be mobilized. This may require tapping funds from the climate and health arenas to complement the energy/development priorities that traditionally drive funding for these activities.

Introduction

Despite efforts over the years, a significant fraction of humanity is still without access to modern (or even adequate) energy. For example, it is estimated that nearly 1.3 billion people remain without access to electricity and 2.6 billion still do not have access to clean cooking energy. Many of these deprived people live in least-developed countries, but, surprisingly, they also are in emerging economies such as India, South Africa and Brazil. The energy situation of this group has implications for their human, social, and economic development.

The development and diffusion of suitable technologies can play a significant role in the mitigation of this situation, often leading to development and climate benefits. Using examples from clean cookstoves and renewable energy in rural areas, this policy brief will illustrate how technology innovation processes can be organized so as to advance the development and deployment of climate-compatible technologies to help meet the energy needs of the world's poor and marginalized populations

The modern-energy gap for the 'bottom of the pyramid'

While energy is seen as being essential to human, economic, and social development, wide swathes of humanity still do not have access to adequate and modern forms of energy. The International Energy Agency's (IEA's) World Energy Outlook 2012 (IEA 2012) estimates that nearly 1.3 billion people remain without access to electricity and 2.6 billion still remain dependent on traditional biomass for their cooking needs, with most of these being in developing Asia and Africa (see Table 1). Furthermore, these numbers will not decline by much under the New Policies scenario of the IEA – by these projections, even in 2030, over 1 billion people still would not have access to electricity and 2.6 billion people would still not have access to clean cooking energy (IEA 2012)

Table 1: Populations without access to modern energy by region, 2010 (millions) (adapted from IEA 2012)

	Without access to electricity		Traditional biomass for cooking	
	Population	Share of pop.	Population	Share of pop.
Developing World	1265	24	2588	49
Africa	*590*	*57*	*698*	*68*
Developing Asia	*628*	*18*	*1814*	*51*
Latin America	*29*	*6*	*65*	*14*
Middle East	*18*	*9*	*10*	*5*
World	**1267**	**19**	**2588**	**38**

Modern energy sources provides a range of services – lighting, refrigeration, communication, mechanical power, thermal energy, etc. – that are important at the household, community, and enterprise level (Practical Action, 2013). To give a few examples, modern forms of energy can greatly advance education (through availability of lighting for studying after sunset, improved teaching infrastructure and tools), health and well being (e.g., through improved health infrastructure and medical services, ability to store drugs and vaccines locally, enhancing availability of clean water), and economic opportunities (e.g., through setting up of enterprises that require electricity or through access to market information).

Therefore the lack of access to modern energy, especially electricity, can limit the availability of these kinds of amenities that underpin development. And in many cases, reliance on traditional or polluting forms of energy can also have deleterious health, environmental or other consequences.

To illustrate with a particularly egregious example, the traditional use of biomass in for household cooking energy has a variety of adverse repercussions within and beyond households. The recently-released Global Burdens of Disease (GBD) study indicates that household air pollution (HAP) from solid fuels (caused mostly by the burning of biomass in traditional cook stoves) is responsible for between 2.7 and 4.5 million excess mortalities worldwide annually and is the fourth-largest risk factor globally in terms of disability-adjusted life years (Lim et al., 2012). Women and children (who are often with their mothers) are particularly affected because they receive the highest exposure to this pollution. More recently, it also has been realized that the products of incomplete combustion of biomass – a number of gaseous compounds as well as carbonaceous aerosols that have greenhouse activity – also have a significant climate warming contribution (Smith 2000, Bond et al. 2013). And lastly, the time spent on gathering biomass for cooking is wasteful, and because it often involves children, can affect their education.

It is for these reasons that the 'energy access' problem is seen as a central part of the sustainable development challenge and received increasing attention by policy-makers in recent years. As a result, there have been numerous national and international initiatives – with many being launched very recently – focusing on this problem.

Notably, the UN Sustainable Energy for All initiative (SE4All) has played a particularly important role in raising the profile of, and moving forward the agenda of, modern energy access. In fact, over a quarter of the commitments under the SE4All pertain directly to energy access (Practical Action, 2013). How successful these commitments will be in addressing the problem, of course, remains to be seen.

Leveraging the power of technology for modern-energy access

"Give me a long enough lever and a place to stand, and I will move the earth." – Archimedes

As with the energy sector more broadly, technology is seen as a critical element of efforts to address energy access in a climate-compatible manner. Yet, as detailed below, there are a number of issues that impede the leveraging of technology for meeting this challenge. Most broadly, these pertain to the development of suitable technologies and products and to their large-scale deployment. That is to say, while the development of climate-compatible technologies for the 'bottom of the pyramid' is a necessary step, it is not sufficient in and of itself.

A challenging context

Much of the world's innovation capabilities are located in industrialized countries, and principally within the private sector, with scientific and technical research being driven largely by market opportunities and, to some extent, the personal motivations of researchers. Not surprisingly, then, the BOP remains mainly neglected, despite exhortations by management gurus such as C.K. Prahalad (2004), in part also because exploiting the market at the BOP is not trivial. As Wilson et al. (2012) note, " 'Business as usual' is unlikely to reach the poor as profit margins and time frames are less attractive." At the same time, it also is well recognized that there is a market failure for public goods such as cleaner energy in the absence of clear market signals (which do not exist yet). The confluence of these two under-represented areas – clean energy for the world's poor – is a devastating combination. The problem is further complicated by the fact the much of the target group live in rural areas of poorer countries. Therefore dissemination strategies and channels – be they efforts to deliver cookstoves or bring electricity – have to work across large and disparate geographies and cultures.

Given this, it is not a surprise that despite recognition of the modern energy gap for the BOP, progress in addressing this challenge has been rather limited. Consequently, particular attention has to be paid to design programmes and policies to overcome the kinds of constraints noted above to deliver at scale modern and cleaner energy technology options for the poor.

Innovation policy to promote climate-compatible technology for BOP

In the absence of well-functioning markets, innovation policy must be particularly careful to focus on all elements of the innovation cycle since traditional market actors – firms, financiers, entrepreneurs, etc. – do not have the incentives to take up the mantle themselves.

Broadly, the success of any technology is contingent on its delivering performance characteristics that are perceived as desirable user at a price that they can afford. But ensuring that such a technology exists and, as and when it does, that it is disseminated to the users, and that it indeed stays in use and delivers the promised performance/ service all requires careful attention to the programme design.

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Facilitating suitable technology development

As a first step, therefore, innovation policy must focus on the development/adaptation of technologies and systems that have suitable and well-defined performance characteristics. In the case of cookstoves, this would be low-cost cleaner-burning designs with emissions low enough to adequately protect human health (since that needs to be a primary focus of improved household energy programmes) while being cheap enough to allow for large-scale dissemination. In the case of rural energy, the specifications of the design may be in terms of required energy service parameters (desired level of output at specified average cost), which also would have the advantage of making it technology neutral, since there are multiple technological options - solar PV, biomass gasification, microturbines, etc. (Kaudinya, et al., 2009) - and different ways to use these technologies in generation systems, depending on local needs (Ockwell et al., 2009). Other performance and design attributes will need to be necessarily specified through interactions with users (those responsible for cooking in households, in the case of cookstoves, or those who are in the business of providing rural energy services - local ESCOs or government agencies - in the case of rural energy) such that these users see resulting technologies as useful and relevant to them. In many cases, given that there is almost an overwhelming array of problems and technological options facing policy-makers, it may be useful to prioritize and focus on opportunities that have large benefits and significant probability of success so as to not spread efforts and resources too thin.

The development of these technologies could be facilitated through traditional policy levers such as public R&D investments or through novel mechanisms such as incentive prizes or advance market commitments that aim to create incentives for technology developers to motivate them to turn their attention to neglected problems. Of course, it is not necessary that technologies must be developed locally – international collaboration, or even transfer of technology from other countries, may be effective options (see, for example, Ockwell 2009), although regardless of the approach, it must be again emphasized that the design of the final product must reflect the needs of local users.

Policy support may also be needed to facilitate the establishment of production facilities (again, through market creation mechanisms and/or by making available to firms technical and financial resources that may be required for such a purpose). In addition, additional policy elements such as development of standards and certification help manufacturers by bringing standardization and transparency to the market; in addition, certification also gives confidence in the products to the users.

Advancing deployment

Dissemination of these technologies, given the geographical, cultural, and socio-economic diversities of the target groups, requires a flexible and strategic approach that very much takes into account the specifics of the locale under consideration. Thus it may be easier to initiate a programme by focusing on users and environments that are seen as most conducive to success, as was the case in cookstove programmes in Kenya and China (Smith 1993; Ramani 2009). Once the market has been created and there is confidence in the technology, further scale-up likely will be easier.

Particular effort may be needed in early-stage dissemination, where users may be risk-averse in trying out new technologies. This is as true in the case of households, where 'tradition' may be well entrenched as in the case of local entrepreneurs or existing industries in rural areas, where the margins are small enough that any perturbation may have catastrophic financial consequences. Financiers may also view the deployment of untested technologies as a credit-risk (Martinot, 2001). Therefore, alleviating the risk perception of the early users and other relevant actors is key to successful market creation; at the same time, early market-penetration programmes can also yield valuable insights about programme design for scale up.

Exploration with various models for deployment for sustainability and replicability may be required (see, for example, Martinot, 2001; Karkezi, 2002; Shrimali et al., 2011). Local entrepreneurs and ESCOs may be particularly key players in these activities because of their understanding of the local context – engagement with them can not only increase the likelihood of successful delivery to end-users (and some level of follow-on support) but also create livelihood opportunities at the local level. Piggy-backing on existing dissemination channels in rural areas – for example, those for agricultural technologies or household appliances – may also be fruitful in some cases. It may also be possible to provide energy access via community-scale services, e.g., children studying at school after sunset where the lighting might be provided by climate-compatible technologies, village agricultural processing equipment provided as a community service; or even small business services provided at the community scale.

In many cases, users may also require financing support if they do not have the financial wherewithal for the up-front purchase of the technologies. Additionally, just as with commercial technologies, information dissemination and marketing efforts that bring awareness to consumers are key to large-scale uptake.

Coordinating actors, activities and programmes

As in any case of technological innovation, multiple actors and networks need to be coordinated, with different actors and networks operating for different parts of the innovation chain. For example, for the early stage, bringing together actors with relevant technical expertise and bringing clarity to performance specification and assessment. The constellation of actors will also be different for different technologies and often even in different locations – in fact, in case of technologies for the BOP, nontraditional actors such as NGOs may play an important role. The design of policies and institutions to promote the development and dissemination of these technologies has to take this variation into account. This is precisely why it is imperative to learn from past experiences and give systematic thought to the design of innovation policies and institutions to promote climate-compatible technologies for helping provide modern energy services to the poor.

As mentioned earlier, there also has been the emergence of numerous new initiatives to address the energy access challenge. These include broad programmes such as the Energising Development programme, which covers multiple energy areas (household cooking, lighting, industrial productive uses, and social infrastructure) and is supported by a number of bilateral donors: and those that are focused on specific areas such as the Global Lighting and Energy Access Partnership (Global LEAP), focused on lighting, and the Global Alliance for Clean Cookstoves, focused on household energy. The International Organization for Standardization (ISO) has also facilitated an International Workshop Agreement (IWA) that aims to provide guidance for rating cookstoves on fuel use/efficiency, total emissions, indoor emissions and safety (WEO, 2012). While the implementation of any programme to disseminate climate-compatible technologies to provide modern energy services to the poor is at the local level, coordination with such international programmes – to exchange experiences and learning as well as to possibly leverage synergies on technology development – is particularly important. While such coordination is not easy, it does deserves some attention since the potential gains are substantial. Again, this will require local capacity to facilitate such coordination and synergy to maximize gains on the ground.

Building capabilities

Furthermore, as can be imagined, all of the above activities require a range of local capabilities and resources – technical, business, financial, policy – at both the individual as well as organizational level, as is the case for almost any process of technological change. In fact, the gap between the kinds of capabilities needed for BOP innovation, given the additional complexities as compared to innovation for more traditional markets, and what capabilities exist is particularly large. Yet if this gap is not addressed, it is difficult to implement the kinds of innovation processes outlined above. Perhaps the most important of these capabilities for the topic of this policy brief is the capability to take a 'bird's-eye view' for the design of specific programmes that cover the relevant aspects of the innovation cycle for particular technologies in the local context and to coordinate various actors and activities (Chaudhary et al., 2012). Policies aimed at building these kinds of capabilities, especially learning from past experiences, are particularly critical and therefore need special attention, even though capacity-building efforts are notoriously difficult to implement effectively (Sagar, 2000).

Mobilizing finance

Lastly, it must be noted that while most of this document has focused on outlining the key issues regarding elements of the innovation cycle, the availability of financing is necessary to support activities aimed at advancing modern energy access for the poor. According to the IEA, while currently about $9 billion is invested annually in energy access globally, investments of about $49 billion per year would be needed to ensure universal energy access by 2030[1] (IEA, 2012). Therefore there is a need to enhance the public and private funding for supporting these activities. Some portion of the flow of funds expected under the Climate Convention could also be directed towards this goal, as a way to compensate the world's energy poor for their low greenhouse gas emissions. Health ministries as well as health-oriented programmes in donor agencies (multilateral, bilateral, or private) could be another potential source of funds, given the significant health benefits from improved access to modern and clean forms of energy (Smith, 2013).

Box 1: Household Energy

For household energy, liquefied petroleum (LP) gas or natural gas is seen as the most desirable option due to the efficient and clean combustion that is possible with these energy sources (Smith, 2002). Some developing countries, in fact, have in place major programs to provide cooking gas to their poorer citizens – for example, 90% of Brazil's population and 75% of Indonesia's population now uses LP gas. More recently, the Cooking for Life campaign of the global LP gas industry aims to move one billion people to cleaner-burning LP gas by 2030. However, the high cost of gas necessitates subsidies for poor people, which, combined with the volatility in the prices of this energy sources, renders this solution impractical for lower-income, and even many middle-income, countries. Thus, it seems that biomass is likely to remain a mainstay of the energy supply for poorer households in developing countries.

In such a situation, the possibility of using cleaner biomass cookstoves emerges as an obvious possibility and one that has been explored for many years across many countries. There now exists a plethora of cookstove designs, with variations in performance, as well as dissemination programmes, both national and global in nature. In recent years, though, our understanding of the household energy problem also has changed: mitigation of household air pollution and climate change are now seen as the main drivers of technical change in this arena; at the same time, better knowledge of exposure-response relationships and technological possibilities have also allowed us to better specify the desired performance characteristics of cookstoves. While some of the recent designs have made significant progress, we still need to push further since it has become clear that we need radically-clean technologies that approach the emission of gas stoves to adequately protect human health. At the same time, other product features such as attractive and robust design and low cost are critical for facilitating uptake among the users. However, the mere existence of suitable cookstoves is not enough to guarantee, or even drive large-scale dissemination. Successful deployment at scale of such technologies requires overcoming a range of cultural, organizational, and resource-constraint challenges and requires careful attention to design of the dissemination programs, including staregic and flexible approach to dissemination, as well as supprting activities such as development of standards, certification, and information dissemination activities.

Source: Sagar (2013)

[1] This includes investments expected under their New Policies scenario as well as additional investments needed to meet the universal energy access objective

Summary of recommendations

Technology can play an important role in addressing, in a climate-compatible manner, the energy-access challenge faced by a significant fraction of the global population. However, leveraging the potential of this technology will require paying attention to, and support for, the full innovation cycle; i.e. technology development/adaptation that is based on an understanding of user needs and local context, large-scale production, and technology deployment (early-stage as well as subsequent scaled up). This requires marshaling technical, business, finance, and other resources as well policy approaches/instruments that are relevant to these various stages.

Given that each stage of the innovation cycle will involve multiple actors that contribute different kinds of expertise and resources, coordination and sharing of learning among actors within any technology programme – and across programmes – is key to smooth and time-bound progress.

A strategic approach to this process may be particularly useful in terms of focusing on market/user segments that have the greatest likelihood of success. This would not only help initiate a market for these technologies, but also develop confidence amongst the users.

Organizing for such innovation – including the coordination as well as strategic planning – and executing successfully requires human and institutional capabilities. Therefore a focus on the development of these capabilities has to be given particular attention.

Lastly, financing to support the development and large-scale deployment of climate compatible technologies for the BOP needs to be significantly enhanced. It should be possible to leverage multiple sources of finance (development, climate, health) since enhanced energy access for the poor in a climate-compatible fashion offers significant gains on all these fronts.

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