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Powering Development with Renewable Energy Technologies

OVERVIEW

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PREFACE

As the evidence and impact of climate change increase, so does the urgency to develop new, clean ways of generating and using energy. And as global demand for energy increases, this quest will become even more urgent. This year the population of the planet reached 7 billion. By 2050 it may top 9 billion. All will need access to modern and affordable energy services.

The UNCTAD *Technology and Innovation Report 2011* focuses on the important role of renewable energy technologies in responding to the dual challenge of reducing energy poverty while mitigating climate change. This is particularly timely as the global community prepares for the Rio+20 Conference next year. The Report identifies key capacity issues for developing countries and proposes concrete recommendations for the wider use of renewable energy technologies to promote sustainable development and poverty reduction.

My high-level Advisory Group on Energy and Climate Change stressed that there is an urgent need to mobilize resources and accelerate efforts to ensure universal access to energy. Creating an enabling environment for the promotion and use of renewable energy technologies is a critical part of this effort, as recognized by the United Nations General Assembly when it declared next year as the "International Year for Sustainable Energy for All".

It is also at the heart of my recent launch of the Sustainable Energy for All initiative to help 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, all by the year 2030.

We can tackle both energy poverty and climate change by facilitating investment, enhancing access to technologies, and doing more to help developing countries make a transition to a greener path of economic growth. *The Technology and Innovation Report 2011* helps point the way forward.

BAN Ki-moon
Secretary-General
United Nations

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The report was written by a team comprising Padmashree Gehl Sampath (team leader), Michael Lim and Carlos Razo. Inputs were provided by Dolf Gielen (Executive Director, IRENA Technology and Innovation Center, Bonn), Professor Mark Jaccard, Simon Fraser University, Professor Robert Ayres (INSEAD), Aaron Cosbey (IISD), Mathew Savage (IISD), Angel Gonzalez-Sanz (UNCTAD), Oliver Johnson (UNCTAD) and Kiyoshi Adachi (UNCTAD).

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KEY MESSAGES

On technology and innovation capacity for RETs:

1. A mutually compatible response to the dual challenge of reducing energy poverty and mitigating climate change requires a new energy paradigm. Such a paradigm would have RETs complementing (and eventually substituting) conventional energy sources in promoting universal access to energy.
2. Established RETs, such as solar PV technologies and onshore wind, are experiencing rapid ongoing technological progress and reductions in energy generation costs.
3. RETs are already being deployed on a significant scale in some countries, though this varies by region.
4. Much progress can be achieved in alleviating energy poverty by focusing on rural, off grid applications alongside efforts to establish more technologically and financially intensive grid-based RET applications.
5. In the absence of technological capabilities, national strategies for sustainable economic development are likely to be constantly undermined.
6. Strengthening technological absorptive capacities is essential not only to build R&D capabilities for RETs in the short and mid term, but also to promote adaptation and dissemination of RETs.
7. RETs use should be integrated within broader goals for poverty reduction and job creation for the more economically vulnerable groups in developing country economies.

On the international policy challenges for RETs:

1. There is an urgent need to reposition the debate within the international agenda on climate change so that obligations of countries to mitigate climate change is framed in terms of creating development opportunities for all in an environmentally sustainable manner.
2. Such a repositioning also implies focusing on issues of finance, technology transfer and technology dissemination for developing countries in the context of RETs.

3. The current international finance and technology transfer architecture is fragmented. It needs to be strengthened with the aim of reducing energy poverty while mitigating climate change.
4. International support needs to work hand in hand with national frameworks on RETs, complementing efforts in three critical areas: increasing financial resources for RETs, promoting greater access to technology and enabling greater technological learning within the green economy and the Rio-plus-twenty framework.
5. The diffusion of RETs in developing countries involves much more than transferring technology hardware from one location to another. This Report, noting the complexity of technological change in different contexts, calls for targeted international support to foster RETs-related learning. Such support could include the following elements:
   (i) an international innovation network for LDCs, with a RET focus, that seeks to facilitate knowledge accumulation and innovation in LDCs.
   (ii) global and regional research funds for RETs deployment and demonstration, that focus attention on making resources available to adaptation and incremental innovations in RETs for use in a wide variety of contexts.
   (iii) an international RETs technology transfer fund that is dedicated to facilitating private-private and private-public transfer of technology for RETs.
   (iv) an international RETs training platform that promotes capacity building and skills accumulation in developing countries.
6. More support could take the form of augmenting and further strengthening the recently proposed technology mechanism within the UNFCCC, particularly by increasing its focus on RETs.

On national policy frameworks for RETs:

1. National governments in developing countries can play a pivotal role in combining conventional sources of energy with RETs in ways that will not only help reduce energy poverty, but also simultaneously promote climate-friendly solutions to development.
2. This Report proposes that developing countries adopt a national integrated innovation policy framework to create policy incentives in national innovation policies and national energy policies for the greater use, diffusion, production and innovation of RETs.

3. Such a policy framework would have five key functions:
   (i) Defining policy strategies and goals;
   (ii) Providing policy incentives for R&D, innovation and production of RETs;
   (iii) Providing policy incentives for developing greater technological absorptive capacity, which is needed for adaptation and use of available RETs;
   (iv) Promoting domestic resource mobilization for RETs in national contexts; and,
   (v) Exploring newer means of improving innovation capacity in RETs, including South-South collaboration.
4. Not all of the policy options proposed in the Report are available or applicable to all developing countries and LDCs.
5. Incentives for RETs production and innovation can be entrenched into the wider innovation policy framework and energy policies of countries through a variety of policy measures.
6. For the poorer countries, the ability to undertake large-scale R&D or establish significant manufacturing capacity will be constrained by the relatively small size of their domestic markets, lack of access to finance and weak institutional capacity. In such cases, countries should consider incentives to build greater absorption capacity in RETs and revisit their energy subsidy policies.
7. Incentive structures can start small, on low-scale projects, designed to encourage private sector solutions to renewable energy technology development and deployment challenges in rural settings.
8. Developing countries will face different problems in RETs promotion, production and innovation, depending on their respective starting points. Nevertheless, for all developing countries, RETs present real opportunities for reducing energy poverty, and the right policies could influence the extent of benefits that could be derived from RETs use, adaptation and dissemination.

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RENEWABLE ENERGY TECHNOLOGIES, ENERGY POVERTY AND CLIMATE CHANGE

Sustained economic growth of the kind that leads to continuous improvement in the living standards of all people through poverty reduction rests on assuring access to energy for all. Such a global energy access agenda requires a greater focus on energy generation and use from existing resources while minimizing waste. However, the use of conventional energy sources (primarily fossil fuels) are believed to have led to a rise in greenhouse gas (GHG) emissions and to a resulting increase in global average temperatures since the mid-twentieth century. The fundamental conclusions of the most recent assessment report of the IPCC are that climate change is the result of human activity, that the ongoing rate of climate change will have devastating effects if left unchecked, and that the costs of action for mitigation and adaptation would be significantly lower than the costs of inaction.[1] Therefore from a climate change perspective, there is a need for all countries worldwide to embark upon low-carbon, high growth trajectories. It also requires promoting the use of other, newer or more cost-effective energy sources in all countries, which could complement the conventional energy supplies predominantly in use today. Renewable energy (RE) sources offer one such distinct possibility, and established renewable energy technologies (RETs) can complement more traditional sources of energy, thereby providing countries with varied energy options within their national energy matrices to suit their specific needs and conditions. Given their enormous potential, there is growing interest in the current and future role of RETs in national energy supply systems worldwide.

This, however, is not an easy task for all developing and least developed countries (LDCs), since the greater use of RETs for energy supply and industrial development is dependent on building technological capabilities. Against this broad background, the *Technology and Innovation Report* (*TIR) 2011* analyses the important role of technology and innovation policies in expanding the application and wider acceptance of RETs, particularly in the context of developing countries. Technology and innovation policies can promote and facilitate the development, acquisition, adaptation and deployment of RETs to support sustainable development and poverty reduction in developing countries and LDCs.

Four current trends lend a new urgency to the need to explore how far and how easily RETs could serve energy needs worldwide. First, ensuring universal access to conventional energy sources using grids entails high costs, which means that developing countries are unlikely to be able to afford the costs of linking additional households, especially those in rural areas, to existing grids. Second, the climate change debate has injected a greater sense of urgency into searching for newer energy options, as a result of both ongoing policy negotiations and the greater incidence of environmental catastrophes worldwide. Third, from a development perspective, the recent financial and environmental crises have caused major setbacks in a large number of developing countries and LDCs, resulting in their further marginalization from the global economy. The LDCs and many developing countries suffer from severe structural vulnerabilities that are a result of their patterns of integration into the global economy. The international community needs to promote low-carbon, climate-friendly development while fostering inclusive economic growth in these economies as a matter of urgency. Lastly, there are extreme inequalities within developing countries themselves, and lack of access to energy affects the poorest of the poor worldwide, impeding their ability to enjoy the basic amenities of modern life that are available to others at the same level of development.

Within the United Nations Framework Convention on Climate Change (UNFCCC), polarized positions on who should shoulder responsibility for the current state of emissions and share the financial burden for mitigating climate change are based on the erroneous belief in the incompatibility of the dual challenges of promoting industrial development and mitigating climate change. Developing countries, in particular, face the challenge of promoting industrial development – a fundamental prerequisite for poverty reduction and equality in their societies – while reducing their reliance on conventional energy sources that have played a central role in global economic growth until recently.[2] Most of these countries also remain far more vulnerable to most of the environmental threats arising from climate change.[3]

However, the advantages of using RETs will not accrue automatically in developing countries. Although many of the RETs needed for meeting a larger share of the global energy demand already exist, or are on the verge of commercialization, the knowledge and technological capabilities required for their transfer to developing countries and LDCs are not easily accessible. Developing countries will need to strengthen their innovation systems,[4] policy frameworks and linkages to enable wider RET dissemination and to promote a greener catch-up process. Promoting greater access to RETs and support for use and adaptation of these technologies

through all means possible will be important to enable developing countries to sustainably integrate these processes into efforts aimed at capital formation and transformation of their productive structures.

There is a need not only for strong domestic technology and innovation policies, but also for greater international efforts to make the international trade and intellectual property rights (IPRs) regime more supportive of the technological needs of developing countries and LDCs. International support to developing countries through various channels should also include financial support and North–South, South–South and triangular cooperation, as well as effective technology transfer mechanisms. All of these will be necessary complements to the development of local capacities for RETs.

This *TIR* identifies five distinct issues that stand out in the debate on technology and innovation of RETs, which are of particular relevance for all developing countries and LDCs. First, structural transformation that supports the economic development of countries relies strongly on the growth of national technological capabilities. At present, inadequate energy supply is a constraint that applies not only to the manufacturing sector, but also to other sectors that are potentially important to the process of industrialization and development, such as services, tourism and agricultural processing, which depend on reliable, high-quality power supply. It is therefore important to recognize the virtuous relationship between energy security and technological capabilities: energy security is a key aspect of the physical infrastructure required for growth, and technological capabilities are a fundamental prerequisite for greater adaptation and use of RETs within domestic economies.

Second, incoherent, and often conflicting, policy developments at the multilateral level tend to adversely affect national aspirations for technological empowerment in developing countries. Although climate change will affect all countries and communities worldwide, developing countries (especially LDCs) will shoulder a disproportionate burden from the fallout resulting from climate change, including increasing climatic variations, extreme weather events and natural disasters. The ongoing debates on climate change reflect the diverse positions of countries on how the burden should be shared.

Third, the issue of greater transfer of climate-friendly technologies that has been a key element in the global debate on climate change is intricately linked to technology and innovation infrastructures in countries. In the RE sector, recent evidence shows that basic approaches to solving technological problems have long been off-patent,

and therefore can be adapted and disseminated in developing countries *provided* that some technological prerequisites are met. This points to the need for greater attention to strengthening the technology absorptive capacity of countries through coordinated policy support, in addition to making existing technologies available and assisting in their greater diffusion.

Fourth, RETs will remain a distant goal as long as they are prohibitively expensive. Innovation in RETs is moving at a fast pace globally, but left on its own, or left to the "market", it is unclear to what extent this pace will continue globally and to what extent it will lower the prices of these technologies for use at the individual household and firm level in the medium term.

Finally, RETs form part of the wider debate on emerging patterns of investment and technology that fall under the umbrella of the "green economy". At a fundamental level, the concept of the "green economy" itself has been highly contested. Some argue that calling for large-scale investments in developing countries to facilitate the transition to a green economy imposes uneven costs, thereby creating an additional burden on already disadvantaged groups of people. The challenge is to ensure that the green economy concept, which will also be the focus of the Rio+20 framework, is structured in a way that it does not adversely affect ongoing productive activities in developing countries while helping their transition to "green" modes of development. Numerous issues will need to be addressed in this context, including patterns of trade, technological upgrading and specialization.

Analysing these five issues at length, the *TIR 2011* argues that RETs can bring numerous benefits to developing countries. The potential impacts of RETs in terms of reducing energy poverty, generating employment and creating new production and innovative activity add to their environmental advantages. Several established RETs have significant potential to contribute to a broad range of development goals. It is beyond the scope of this Report to address the whole range of policy implications of all RETs in the very different contexts of the various categories of developing countries. It therefore focuses on those that are (i) already mature enough to make practical contributions to policy objectives in the short term, but are sufficiently recent in their commercialization to present challenges with which policymakers may be less familiar; and (ii) particularly appropriate to the objective of reducing and eventually eliminating energy poverty in developing countries as complements (and eventually substitutes) to conventional energy sources.

THE EXPANDING ROLE OF RENEWABLE ENERGY TECHNOLOGIES

Some RETs are well established

RETs are a diverse group of technologies that are currently at different levels of maturity (box 1). Those based on wind, geothermal, solar thermal and hydro are mature technologies and are already being deployed widely. Others, including

Box 1: Established and emerging renewable energy technologies

Solar energy technologies capture energy from the sun, either as heat or as electricity, through conversion by solar PV panels. There are three main classes of solar energy technologies: concentrating solar power (CSP) systems; solar thermal systems for heating residential and commercial buildings (which can be either active or passive in nature) and solar photovoltaic (PV) power systems.

Wind energy technologies, mainly wind turbines, use kinetic energy from air currents arising from uneven heating of the earth's surface to generate electricity. The variations are mainly in terms of the size and location of the units. The two main classes are onshore and offshore.

Biomass energy technologies use both traditional and more sophisticated methods (referred to as modern biomass power) to produce useful energy primarily from wood residues, agricultural waste, animal waste and municipal solid waste. Traditional biomass (wood and charcoal), "modern biomass" (i.e. collecting, pre-processing and delivering combustible cellulosic materials to electric power plants or chemical plants) and biofuels are three categories of biomass.

Hydropower technologies use power generated by harnessing the flow of water through a hydraulic turbine or equivalent. Small and large hydropower systems are the most mature of the RETs, and have been a relatively important source of electric power production for many decades in many countries (REN21, 2005).

Geothermal technologies extract energy from existing reservoirs of steam or hot water in porous rocks beneath the earth's surface. Heat can also be reached by drilling deep enough at any location using an engineered geothermal system (EGS), and brought to the surface as hot water or steam to produce heat or electric power.

Ocean energy can be defined as energy derived from technologies that utilize seawater as their motive power, or harness the water's chemical or heat potential. This form of renewable energy from the ocean comes from five distinct sources: wave energy, tidal range (or tidal rise and fall), tidal and ocean currents, ocean thermal energy conversion (OTEC) and salinity gradient (or osmotic power).

Source: UNCTAD, Technology and Innovation Report (2011).

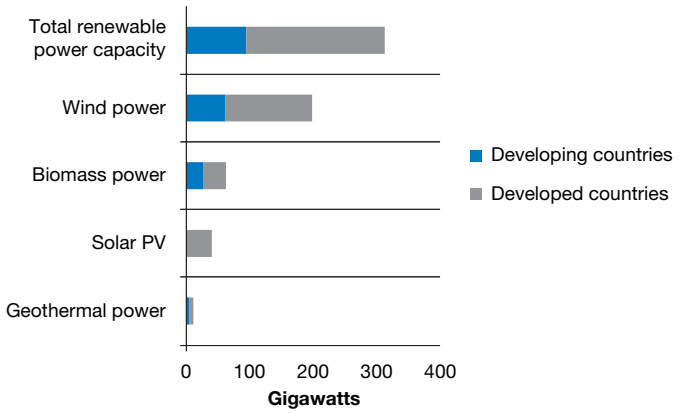
second-generation biofuels and ocean energy, remain at varying stages of pre-commercial development. Although there are problems of intermittency associated with some of them (for example, in the provision of solar energy, where the sun is available for only a limited number of hours per day), they are very versatile in that they can be deployed in various configurations, either alone or, often, in combination with conventional energy technologies. Therefore they offer the potential to contribute significantly to alleviating energy poverty in diverse situations.

The *TIR 2011* focuses primarily on RETs based on wind, solar and modern biomass sources for electricity generation, either in centralized or decentralized facilities. These are among the most important and fastest growing RETs in developing countries (see figure 1 for the shares of various RE sources for power generation). There are also non-electric applications of REs, such as biofuels that are used for transportation, space heating, hot water and cooking (e.g. by solar cookers).

The role of RETs in alleviating energy poverty is growing

On a global scale, although the various advantages of RETs are increasingly being recognized, established fossil fuel sources still dominate energy supply at present, providing up to 89 per cent of all global energy. In 2008, RE sources (including large

Figure 1: Renewable electric power capacity (excluding hydro), end 2010



Source: *UNCTAD, based on REN21 (2011).*

Note: *Estimates of electric power generation by solar PV installations in developing countries are from REN21 (2010). Other technologies not included in the chart, such as solar thermal power and ocean (tidal) power, present low levels of generation capacity: 1.1 and 0.3 gigawatts (GW) respectively.*

hydro installations) accounted for 12.9 per cent of global primary energy supply, whereas the bulk was supplied by fossil fuels (including oil, gas and coal). However, a large proportion of the global population cannot afford these conventional energy supplies. According to estimates of the International Energy Agency (IEA), over 20 per cent of the global population (1.4 billion people approximately) lacked access to electricity in 2010. South Asia has the largest absolute numbers of people without such access (42 per cent of the world total), in spite of recent rapid progress. Taking the entire population of this subregion, 38 per cent have no access to electricity, and within this figure, 49 per cent of people living in rural areas lack access. In relative terms, sub-Saharan Africa is the most underserved region, with 69.5 per cent of the population having no access to electricity, and only a meagre 14 per cent of the rural population having access (table 1).

Eliminating energy poverty and promoting greater access to energy for economic development therefore requires serious consideration of how RETs could complement and/or even substitute conventional energy sources. Will such a new energy paradigm that envisages a greater role for RETs be able to create greater employment? Could those RETs be deployed in remote rural areas that are hard to

Table 1: Access to electricity, and urban and rural electrification rates, by region, 2009

Region	Number of people without electricity (millions)	Electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
Africa	**587**	**41.9**	**68.9**	**25.0**
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.3
Developing Asia	**799**	**78.1**	**93.9**	**68.8**
China and East Asia	186	90.8	96.4	86.5
South Asia	612	62.2	89.1	51.2
Latin America	**31**	**93.4**	**98.8**	**74.0**
Middle East	**22**	**89.5**	**98.6**	**72.2**
Developing countries	**1 438**	**73.0**	**90.7**	**60.2**
OECD and transition economies	**3**	**99.8**	**100.0**	**99.5**
World total	**1 441**	**78.9**	**93.6**	**65.1**

Source: Reproduced from IEA (2010).

connect to the conventional energy grid? Will such RETs be applicable and easy to use by individual users, but at the same time have the potential for scale-up within enterprises, firms and sectors? Would they alleviate, at least partially, the difficulties faced by vulnerable social groups affected by poverty (e.g. rural populations, women, children and indigenous groups) so that they can devote more time and attention to income-generating and other activities?

A significant aspect of RE use is that they offer the possibility of devising semi-grid or off-grid rural installations that promote greater access to energy in developing countries than that provided by conventional energy sources which rely extensively on grid connections. Of the 1.4 billion people not connected to electricity grids globally, approximately 85 per cent live in rural areas. Because of their possibility of use in non-grid or semi-grid applications, RETs can be an important means of energy supply in areas where other energy sources are not available, such as in isolated rural communities. Such decentralized, off-grid applications of RETs are already in relatively wide use in developing countries, where they provide cost-effective energy solutions that bring significant benefits to local communities.

RETs such as solar pumps, solar PV installations, small wind, mini-hydro and biomass mini-grids offer higher potential and cost advantages than traditional grid extension. They can be a reasonable option for providing some degree of access to energy, particularly in rural areas in developing countries and LDCs where national energy grids are unlikely to expand in the near future. Arguably, some of these applications are small in scale and do not make much of an impact on energy provision at the national/global level, but they can still play an important role in reducing energy poverty at the local/rural level. In these cases, RETs offer a realistic option for eradication, or at least for alleviation, of energy poverty.

Technological progress and greater investments and deployment are lowering costs of established RETs

There has been rapid ongoing technological progress in some RETs, such as solar PV technologies and onshore wind energy, with accompanying reductions in energy generation costs. The cost competitiveness of RETs relative to conventional energy sources is also improving, and can be expected to improve even further with continued technological progress and higher investment in their development, production and deployment. The prices of solar PV systems, for instance, have been falling extremely rapidly. During the 18 months leading to June 2010, prices of new solar panel modules fell by an estimated 50 per cent. And in some off-grid

and mini-grid applications some RETs were already competitive with conventional energy in 2005, even with the relatively low oil prices prevailing at that time. It is reported that in Africa, Asia and Latin America, the demand for modern energy is driving the use of PV for mini-grid or off-grid solar systems, which in many instances are already at price parity with fossil fuels. This implies that for precisely those applications which may be most suitable for isolated communities (i.e. decentralized applications that do not require connection to the national or regional energy grids) RETs may be at their most cost-competitive. Rising, and increasingly volatile, oil prices and growing investments in RETs (box 2) may also be contributing to this trend. However, additional technological improvements that could help to better integrate RE into the existing energy infrastructure (including through the development of smart energy grids) and augment the storage capacities of RETs will be valuable in promoting their cost competitiveness.

Despite the ongoing surge in the deployment of RETs, at present they account for only a small fraction of global energy consumption. The *TIR 2011* stresses that there is still enormous technical potential for power generation from RETs, and argues that such RETs are likely to play an increasingly important role in meeting global energy demand as continued technological progress, additional investment and further deployment lead to cost reductions over the medium and long term globally. The analysis in the Report shows that RETs will continue to evolve as complements to existing energy sources globally, with the eventual aim of replacing conventional energy in the long term. For developing countries and LDCs, this is a positive trend. The actual speed and extent of deployment of RETs and the role they will eventually play will depend critically on the policy choices that are made today and in the future. The policy issues that need to be considered within national frameworks for technology and innovation and the ways and means of international support will be critical for harnessing the potential of RETs for poverty reduction and sustainable development.

STIMULATING TECHNICAL CHANGE AND INNOVATION IN AND THROUGH RENEWABLE ENERGY TECHNOLOGIES

Technology and innovation capacity and reliable energy supply are intricately linked

Uninterrupted and reliable energy supply is an important stimulant to innovative capacity and economic growth. Indeed, a number of studies underline a direct causal relationship between the low supply of electricity and stunted economic

Box 2: Growing investments in RETs

Global investments in RETs have increased markedly during the past decade, rising from a total of $33 billion in 2004 to $211 billion in 2010, and they have been growing at an average annual rate of 38 per cent over that period, according to the most recent estimates available. Both developed and developing countries are participating in this growth, although there is a need for expanding RETs-related investments in smaller developing countries, particularly LDCs. The increase in investments has been closely associated with technological improvements and declining costs of RETs production, and has continued despite the global financial crisis and recession of 2008-2009 and the resulting drop in conventional energy prices. Recovery of investments was brisk in 2010 and prospects seem bright for their continued growth (box table 2.1).

Box table 2.1: Global investments in renewable energy and related technologies, 2004–2010 ($ billion)

	2004	2005	2006	2007	2008	2009	2010	Average annual growth rate 2004–2010 (%)
Investment in technology development of which:	5.3	4.7	5.7	6.7	8.2	7.6	11.0	14.6
Venture capital	0.4	0.6	1.3	1.9	2.9	1.5	2.4	46.2
Government R&D	1.1	1.2	1.3	1.5	1.6	2.4	5.3	35.1
Corporate R&D	3.8	2.9	3.1	3.3	3.7	3.7	3.3	-1.5
Investment in equipment manufacturing	0.7	4.8	14.1	25.2	19.4	15.6	18.5	139.0
Investment in RE projects of which:	26.9	47.9	72.6	109.0	140.3	141.1	193.4	41.0
Small distributed capacity	8.6	10.7	9.4	13.2	21.1	31.2	59.6	41.9
Total investment in RETs	33	57	90	129	159	160	211	38.3

Source: UNCTAD, based on UNEP and Bloomberg (2011).

Note: The data are estimates provided by Bloomberg New Energy Finance. They exclude large hydro, but include estimates for R&D investments by the private sector and governments as well as investments in small distributed RE projects.

growth. At the same time, technology and innovation capabilities are important for promoting R&D and innovation to produce state-of-the-art RETs, and for creating a critical base of knowledge that is essential for adapting and disseminating RETs. A critical threshold of technological capability is also a prerequisite for making technical improvements to RETs that enable significant cost reductions so that they can be deployed on a larger scale in developing countries. The success of RETs-related technology transfer initiatives also depends on the ability of actors in developing countries to absorb and apply the technologies transferred. The absence of, or limitations in, technological and innovation capabilities is therefore likely to constantly undermine national strategies for sustainable development based on the greater use of RETs. This virtuous relationship between RETs and technology and innovation capacity needs to be recognized and fostered actively.

Countries' capacities for technological absorption need to be strengthened through coordinated policy support, but an additional priority will be to make existing technologies available and assist in their greater diffusion. As noted earlier, while innovation in RETs is moving at a fast pace globally, ensuring this continues will require policies that promote the wider adaptation and deployment of RETs. In the context of the current state of underdeveloped energy infrastructure in developing countries and LDCs, RETs could not only help to reduce energy poverty in many novel ways; they could also help reduce social inequalities through the creation of new jobs associated with the application of RETs. Public policy therefore has an important role to play in this regard, in addition to tipping the balance towards energy mixes that give prominence to RETs development in developing countries.

Innovation policy frameworks for RETs are a fundamental requirement

Innovation systems in developing countries are fundamental to shaping the capacity for the technological learning needed for adaptation, use, production and R&D-based innovation of RETs. There are several features of technology and innovation unique to RETs compared with other sectors that have been the focus of many policy studies. First, there is already a well-established energy system globally, and RETs are technologies that seek to provide alternative solutions to achieve the same results using natural and renewable resources of different kinds (such as sun, wind and water). Their unique selling point is that they offer environmentally friendly solutions to energy needs for the same service, namely the supply of energy. This is different from innovation in other sectors where competition is structured around the provision of newer products and services at reasonable prices.

Second, the intermittency issues related to RETs necessitate a systemic approach to promoting innovation in the sector. Evidence shows that intermittency of different RE supplies can be dealt with quite easily within electricity systems when solutions are designed from a systemic perspective.[5] A systemic treatment of RETs is also important from another perspective, namely, the management of demand for energy. The end-use dimension (i.e. how many people can access a particular supply and how effectively it can be provided) will need to play a major role when considering RETs as a means of alleviating energy poverty in developing countries. Thus a systemic perspective should give due consideration to the demand dimension when designing on-grid, off-grid or semi-grid applications using RETs.

Third, it is often assumed, incorrectly, that technological capability is required primarily for R&D aimed at the creation or development of newer RETs. As the *TIR 2011* shows, technology and innovative capability is also fundamental for other aspects, such as:

(i) Making minor technical improvements that could enable significant cost reductions in production techniques, adaptation and use; and

(ii) Adaptation, dissemination, maintenance and use of existing RETs within key sectors of the economy, which depend not only on the availability of materials, but also on diverse forms of knowledge.

Fourth, in developing countries, there is an urgent need to promote choices in innovation and industrial development based on RETs. These choices may be different depending on the conditions in the country and the kind of RE resource(s) available. The specific characteristics of different RETs, varied project sizes and the possibilities for off-grid and decentralized supply, imply many new players, both in project development (new and existing firms, households and communities) and in financing (existing lenders, new microcredit scheme, government initiatives).

Therefore, strengthening national frameworks for technology and innovation in developing countries is a necessary pre-condition for ensuring increased use and innovation of RETs through: (i) the greater integration of RETs within socio-economic development strategies of countries; (ii) creation of capacity for increased technology absorption in general, and in RETs in particular; and (iii) express policy support aimed at significantly integrating RETs into the national energy mix by tipping the balance in favour of RETs development, production and use.

National governments need to tip the balance in favour of RETs

There is an urgent need for government action aimed at substituting patterns of current energy use with reliable, established RETs. While off-grid RETs (especially modern biomass-based ones) may be relatively easy to deploy, many still remain very expensive at the scales required to make an impact in developing countries, despite rapid technological advances. For example, a study by the IEA (2009) came to the conclusion that in the United States, electricity from new nuclear power plants was 15–30 per cent more expensive than from coal-fired plants, and the cost of offshore wind power was more than double that of coal, while solar power cost five times as much. Changing from the current global situation of no energy, or unreliable and often undesirable sources of alternative energy (such as traditional biomass), to one where industrial development begins to pursue a cleaner growth trajectory is essential for driving down the costs of RETs.

Each time investment is made in generating more energy through RETs, there is not only a gradual shift in the energy base; it also has a significant impact on the capacity of RETs to supply energy more economically. For example, according to recent reports, every time the amount of wind generation capacity doubles, the price of electricity produced by wind turbines falls by 9–17 per cent.[6] This holds true for all RETs: with each new installation, there is learning attached as to how the technology can be made available more effectively and efficiently in different contexts so as to lower costs over a period of time.

Government action will need to focus on two very important areas of intervention: addressing systemic failures in RETs, and tipping the balance away from a focus on conventional energy sources and towards RETs. Systemic failures in the RETs sector are varied and emerge from sources other than just the market. They can be caused by technological uncertainty, environmental failures or other systemic factors. Therefore, it will be important for government intervention to address these failures.

Policy incentives, critical for inducing a shift towards the wider application of RETs in the energy mix of countries, need to be designed and articulated at the national and regional levels so that collective actions can be fostered. Most importantly, energy production should cater to local needs and demand in countries, for which a systemic perspective is necessary. Policy support needs to be directed at mobilizing greater domestic resources to foster RETs development and use, in addition to providing increased access to the most advanced, cost-cutting technological improvements to established RETs.

Governments can play a vital role in making RETs feasible at each level: use, adaptation, production and innovation. Government agencies and the policy framework should aim at:

(i) Promoting the general innovation environment for the development of science, technology and innovation;

(ii) Making RETs viable; and

(iii) Enabling enterprise development of and through RETs.

This requires governments to adopt an agenda of proactively promoting access to energy services of the kind that is conducive to development, while also focusing on the important positive relationship between technology and innovation capacity and increased use of RETs. Greater international support for developing countries will be critical on both these fronts.

INTERNATIONAL POLICY CHALLENGES FOR ACQUISITION, USE AND DEVELOPMENT OF RENEWABLE ENERGY TECHNOLOGIES

The international discourse needs to be framed more positively, with a focus on mitigating climate change and alleviating energy poverty

Efforts at the national level aimed at harnessing the virtuous relationship between RETs-related technology and innovation capacity for inclusive economic development and climate change mitigation need to be strengthened through greater international support. At the international level, discussions and negotiations on climate change and the green economy have gained momentum in recent years. A major focus of those discussions relates to environmentally sustainable technologies, or low-carbon, "clean" technologies,[7] as a means of contributing to climate change mitigation and adaptation globally.[8] This is a very important global goal, which will serve the needs of developing countries in particular, given the evidence that climate change is having disproportionately damaging impacts on those countries. However, along with efforts to mitigate climate change, there needs to be an equally important focus on eliminating energy poverty in developing countries, not only to improve people's living conditions but also to boost economic development.

The *TIR 2011* stresses upon the need for repositioning issues within the international agenda, whereby the obligations of countries to mitigate climate change are framed in terms of creating development opportunities for all in an environmentally sustainable manner. Central to this repositioning is the triangular

relationship between equity, development and environment. From this perspective, recognition of the right of all people worldwide to access energy services is long overdue and needs to be addressed. Developing countries, especially the least developed, have experienced a particularly large share of natural disasters, such as hurricanes, tornados, droughts and flooding, as a result of changing climatic conditions. According to recent estimates, 98 per cent of those seriously affected by natural disasters between 2000 and 2004 and 99 per cent of all casualties of natural disasters in 2008 lived in developing countries, particularly in Africa and South Asia where the world's poorest people live.

Such a repositioning also implies a greater focus on three key challenges, namely international resource mobilization for RETs financing; greater access to technology through technology transfer and the creation of flexibilities in the IPRs regime; and promoting wider use of RETs and technological learning in the push for a green economy and within the Rio+20 framework. These issues have been and remain central to all debates and decisions of the UNFCCC and the Kyoto Protocol that focus mainly on environmentally sustainable – or clean – technologies, of which RETs form a subset. In highlighting the need for a greater focus on RETs in international discussions, the Report also identifies the main hurdles in all these three policy areas.

International financial support for RETs needs to be strengthened and targeted

A number of estimates have been produced that try to quantify the challenge of adaptation and climate change mitigation. All of them consider slightly different categories of investments that will be needed in the immediate or medium term. The International Energy Agency estimate covers only electricity generation technologies, and therefore excludes investment in transport fuels and heating technologies. While all the estimates are indicative, the definitions of technology and the broad goals assumed in the IEA (2000) are probably the most relevant to the issues under consideration in this *TIR*.[9] The proposal to halve energy-related emissions by 2050 corresponds roughly to the minimum mitigation levels deemed necessary by the IPCC, and the definition of low-carbon energy technologies covers RETs. The IEA's estimates for the level of investments needed are lower than the other estimates in the medium term, at $300–$400 billion per annum up to 2020, but rise thereafter to reach $750 billion by 2030.

This raises questions about the capacity of public finance to support the rapid and widespread deployment of RETs as part of adaptation efforts and the role

of international support. There are a number of known sources of finance at the multilateral and regional levels such as the World Bank's Climate Investment Funds, the Clean Technology Fund and the newly announced UNFCCC Green Climate Fund. However, several caveats apply when calculating the amount of finances available under all the funding figures. Some of the funds are multiyear commitments and often cover mitigation and adaptation. Also, some of the funds are not yet available. Taking all these caveats together, the total amount of annual funding for RETs from public sources is likely to be about $5 billion from the known sources. This figure is far from sufficient when compared to the global needs. The International Renewable Energy Agency estimates that just the African continent would need an investment of $40.6 billion per year to make energy access a reality in a sustainable way.

It is therefore that in the area of finance, support for greater investment in RETs and their use in developing countries is critical today. In response to the global financial and economic crisis, many countries initiated stimulus packages that included funding for efforts to build capacity in those areas of the green economy that display the greatest growth potential. No doubt, the general trend is towards policies that simultaneously aim at securing environmental benefits through increased use of RETs, development benefits through increased energy provision, and economic benefits by increasing domestic capacity in areas that show growth potential.

However, such ongoing efforts in developing countries would be better served if outstanding issues relating to international financial support for RETs could be urgently resolved with the aim of promoting greater innovation, production and use of such technologies. At present, international financing of clean technologies, which is largely multilateral, is highly fragmented, uncoordinated and lacks transparency. It is also woefully inadequate to meet total funding requirements for climate change mitigation and adaptation. While such financing may partly be targeted at RETs, additional international funding for RETs is required as a priority. Coordination of funding sources with the aim of mainstreaming RETs into national energy systems globally should be an important aspect of climate change mitigation efforts. This would not only lead to the development of more efficient energy systems globally; it would also ensure that the financing contributes to greater technological progress towards newer and/or more cost-effective RETs.

Access to RETs and related technology transfer need to be more clearly articulated

Currently, most of the clean technologies needed for developing countries and LDCs are off-patent. Despite this general finding, recent trends show that patenting activity in RETs is on the rise. Following an analysis of these trends against the backdrop of the ongoing negotiations on the draft UNFCCC,[10] the *TIR 2011* suggests that discussions on technology transfer of RETs within the climate change framework should move beyond a narrow focus on the issue of technology transfer to a broader focus on enabling technology assimilation of RETs. Indeed, the recent Climate Change Conference at Cancun in 2010 proposed to strengthen the focus on technology transfer, including the creation of a new technology mechanism to help enhance the technological capacity of countries to absorb and utilize RETs.

Accumulation of technological know-how and learning capabilities is not an automatic process. Learning accompanies the acquisition of production and industrial equipment, including learning how to use and adapt it to local conditions. In order to foster broader technology assimilation, the technology transfer exercise will need to take into account the specific technological dimensions of RETs as well as the nature of actors and organizations in developing countries. The quality of technology transfer should be assessed by the extent to which the recipient's know-how of a product, process or routine activity is enhanced, and not just by the number of technology transfer projects undertaken. A greater articulation of flexibilities under the global IPRs regime in the specific context of RETs is also required.

The green economy and the Rio+20 framework should promote wider use and learning of RETs

In addition to providing critical infrastructure to support the emergence and shift in production structures in developing countries, RETs can serve the goals of their industrial policy by helping those countries' exporters become more competitive in the face of increasingly stringent international environmental standards. However, simply forcing developing countries to use RETs through measures such as carbon labelling and border carbon adjustments may not be sufficient to enable the transition. Indeed, such measures may even have adverse effects on industries in developing countries by acting as barriers to imports, since enterprises and organizations may not have the means (financial and technological) to conform to the new requirements. To ensure that "green" requirements do not place an additional burden on industries in developing countries and LDCs, global efforts

Box 3: Mechanisms to foster RETs-related technology and innovation capabilities

An international innovation network for LDCs, with a RETs focus. To address some of the shortcomings of existing initiatives on technology transfer, a science, technology and innovation centre (an International Innovation Network) was proposed and approved at the UN LDC IV Conference in Istanbul in May 2011. This TIR suggests that a specific focus on enhancing RETs-based learning in LDCs with the purpose of promoting greater access to energy would fit in directly with the currently identified key areas. It could aim at: (a) promoting a network-based model of learning and sharing of experiences of countries on how to use RETs for increasing energy access in rural, mini-grid areas; (b) promoting access to financing opportunities and technology licences needed for upgrading the RE technological base in the private sector in LDCs, by establishing partnerships with both international firms and donor agencies; and (c) establishing an information-sharing mechanism where different kinds of stakeholders could network and work together to enhance the knowledge base in LDCs on RETs use, adaptation, production and innovation.

Global and regional research funds for RETs deployment and demonstration. RETs constitute a key area of particular interest to developing countries, but funding for technology development and demonstration has been lacking. Dedicated funds, whatever their designated organizational structures, could act as the focal point for the coordination of ongoing research, both at the national and regional levels, and among private, public and non-profit organizations. Scaled up technical cooperation and training programmes could complement those funds, and could involve skilled workers from both developed and emerging economies (engineers, teachers and technicians, among others) working on a temporary basis in developing countries and LDCs to help develop local capacity.

An international technology transfer fund for RETs. Firms in developing countries face three critical constraints in finding and accessing appropriate technologies. First, search and information costs on the appropriate RETs for acquisition are high. Second, generally, they sometimes lack the capacities required to negotiate licences for the technologies in question. Finally, firms also lack information on the kinds of similar technologies available, and their relative costs and merits, which limits their ability to make informed choices. A technology transfer fund for RETs could address all three of these issues by acting as a licensing pool for technologies. Such a pool would offer the RETs at a subsidized rate to firms from LDCs and from developing countries with low technological capabilities. Funds generated by these countries' governments themselves, or by donor agencies, or by both jointly, could be used to subsidize the licensing costs to the recipient firms. The organization responsible for the Fund could also provide a database of similar technologies and their relative merits and licensing costs, thereby creating a much-needed service for firms and organizations in developing countries and LDCs. By acting as a clearing house for the licensed technologies, it would also reduce bargaining asymmetries between firms in developed countries on the one hand, and those in developing countries and LDCs on the other.

An international training platform for RETs. Establishing an international training platform specifically for RETs would serve the important goal of creating a skilled staff base across developing countries for the wider use and promotion of RETs in domestic and industrial contexts. The proposed international RETs training platform could operate at two levels: a physical

Box 3: Mechanisms to foster RETs-related technology and innovation capabilities (contd.)

institute based in one or several places throughout the world, which would offer training on various aspects of RETs use, adaptation and production; and a virtual training platform offering online, computerized courses of various kinds. Both forms of training (through the physical centres and the virtual training platform), could provide RETs-related learning in different fields, such as material sciences, marketing, legal issues, energy combinations and RET applications in various industrial fields.

Source: UNCTAD, Technology and Innovation Report (2011).

aimed at climate change mitigation need to be accompanied by international support in finance and technology to help these countries transition to RETs in a strategic and sustainable manner.

Targeted international mechanisms for RETs-related innovation and technological leapfrogging are required

The obvious question for all developing countries and for the global community is whether the BRICS countries (Brazil, the Russian Federation, India, China and South Africa) are special cases. To some extent they are: they have the prerequisites for competitive production of many RETs, such as a workforce with advanced technical training, supporting industries and services in high-tech areas, access to finance, ample government assistance and a large domestic market, all of which seem to favour these larger emerging developing countries over smaller, poorer developing countries and LDCs.

Historically, promoting technological learning and innovation has remained a challenge for all developing countries. The experiences of China, India and other emerging economies show that public support, political will and concerted policy coordination are key to promoting technological capabilities over time. Greater support for education (especially at the tertiary level) and for the development of small and medium-sized enterprises, as well as financial support for larger firms and public science are important. But in addition to such domestic policy support, greater support from the international community is also needed. The *TIR 2011* proposes four mechanisms of international support (box 3). The first of these, the STI Network, was approved at the LDC IV Conference in Istanbul in May 2011.

NATIONAL POLICY FRAMEWORKS FOR RENEWABLE ENERGY TECHNOLOGIES

Integrated innovation policy frameworks at the national level are critical

The *TIR 2011* calls on national governments to adopt a new energy paradigm involving the greater use of RETs in collaboration with the private sector. Such an effort should be supported by a variety of stakeholders, including public research institutions, the private sector, users and consumers on an economy-wide basis. A policy framework that can strike an appropriate balance between economic considerations of energy efficiency and the technological imperatives of deployment of RETs in developing countries and LDCs will be the cornerstone of such an agenda for change. This will necessitate two separate but related agendas. The first should ensure the integration of RETs into national policies for climate change mitigation. The second should be the steady promotion of national innovation capabilities in the area of RETs. The latter entails addressing issues that are not only generic to the innovation policy framework, but also new issues, such as creating standards for RETs, promoting grid creation, and creating a more stable legal and political environment to encourage investments in RETs as an energy option within countries.

The *TIR 2011* proposes an integrated innovation policy framework for RETs use, adaptation, innovation and production in developing countries and LDCs. The concept of such a framework envisages linkages between two important and complementary policy regimes: national innovation systems that provide the necessary conditions for RETs development, on the one hand, and energy policies that promote the gradual integration of RETs into industrial development strategies on the other. The Report suggests that such a framework is essential for creating a virtuous cycle of interaction between RETs and science, technology and innovation.

Such a policy framework would perform five important functions, namely:

(i) Defining policy strategies and goals;

(ii) Enacting policy incentives for R&D, innovation and production of RETs;

(iii) Enacting policy incentives for developing greater technology absorptive capacity, which is needed for adaptation and use of available RETs;

(iv) Promoting domestic resource mobilization for RETs in national contexts; and

(v) Exploring newer means of improving innovation capacity in RETs, including South-South collaboration.

Policy strategies and goals are important signals of political commitment

The use and adaptation of RETs in countries requires the establishment of long-term pathways and national RE targets. These targets, although not necessarily legally binding in nature, would have to be supported by a range of policy incentives and regulatory frameworks. Defining targets is an important signal of political commitment and support, and the policy and regulatory frameworks aimed at enforcing the targets would provide legal and economic certainty for investments in RETs.

Different policy incentives for RETs innovation, production, adaptation and use are important

The successful development and deployment of any technologies, especially relatively new ones such as RETs, needs the support of several dedicated institutions responsible for their different technical, economic and commercialization aspects. Such support can be organizational (through dedicated RET organizations) or it can take the form of incentives to induce the kinds of behaviour required to meet the targets set for RETs. The *TIR 2011* lists various policy incentives for R&D, innovation and production of RETs and those that are aimed specifically at promoting technology absorptive capacity and learning related to RETs, which will be important for their wider use in national contexts (table 2). Many RETs-related policy incentives proposed have already been used by most of the industrialized countries, although developing countries are also increasingly using them or experimenting with their use. Clearly, developing countries and LDCs will need to select policy incentives that are geared to their specific situations and requirements as much as possible.

The policy incentives presented in table 2 and discussed at length in the Report pertain to two policy spheres: the innovation policy frameworks of countries and their energy policies. This is because energy policies often contain measures that have an impact on particular kinds of technologies. Ongoing reforms in the energy sectors of most developing countries offer a good opportunity to establish regulatory instruments and production obligations geared towards promoting investment in RETs and energy production based on these technologies. Policy incentives of both kinds (i.e. innovation-related and energy-related) are important to induce risk-taking by the private sector, to improve enterprise capacity to engage in learning activities, and to promote basic and secondary research in the public sector. Some of the policy incentives could be aimed specifically at the private sector, such as green

Table 2: Elements of national integrated innovation policy frameworks

A NATIONAL INTEGRATED INNOVATION POLICY FRAMEWORK	Policy incentives for R&D, innovation and production of RETs	1. Incentives for innovation of RETs as part of innovation policy frameworks	• Public research grants • Grants and incentives for innovation of RETs • Collaborative technology development and public-private partnerships • Green technology clusters and special economic zones for low-carbon technologies
		2. Innovation and production incentives in energy policies	• Quota obligations/renewable portfolio standards • Feed-in tariffs
		3. Flexibilities in the intellectual property rights regime	• Patentability criteria • Exceptions to granted patent rights • Parallel imports • Compulsory licenses • Competition law and policy
	Policy incentives for greater technological absorptive capacity (adoption and use)	1. Supporting the development of technological absorptive capacity within innovation policy frameworks	• Establishing training centres for RETs • Development of adaptation capabilities • Education, awareness and outreach
		2. Elimination of subsidies for conventional energy sources	• Removal of subsidies for the use of carbon-intensive fuels • Carbon and energy taxes • Public procurement of renewable energy

Source: UNCTAD, Technology and Innovation Report (2011).

economic clusters and special economic zones to boost enterprise activity, whereas others could be hybrid instruments granted to promote both public and private sector activity, such as collaborative public-private partnerships (PPPs). Yet others, such as public research grants, would be offered primarily to the public sector.

Greater domestic resources need to be mobilized for RETs

Financial incentives of various kinds can promote investment in RETs, and facilitate their quicker adaptation and utilization at the national level. These incentives need to be developed with an eye on the co-benefits of using RETs not only for electricity generation, but also more broadly as a tool for industrial development in countries. All stages of the RETs innovation and adaptation process require financing, and will depend on each country's ability to provide a mix of different kinds of financing, including venture capital, equity financing and debt financing. Particularly in developing countries that face several financial constraints on the introduction and uptake of new technologies, governments need to support the private sector in its financing of innovation activities, such as by offering loan guarantees, establishing business development banks and/or mandating supportive lending by State banks. Governments may also directly fund innovation activities through, for example, grants, low-interest loans, export credit and preferential taxation policies (e.g. R&D tax credits, capital consumption allowances).

South-South collaboration needs to be fostered

South-South collaboration presents new opportunities not only for increasing the use and deployment of RETs through trade and investment channels, but also through technology cooperation, and this can be facilitated by governments, intergovernmental organizations and/or regional development banks. Such cooperation can also be mediated by private sector owners of RETs, although this is less frequent. Technology cooperation can take several forms, ranging from training foreign nationals in the use and maintenance of RETs to supporting research in partner countries to adapt existing technologies to local needs. It can also include outright grants of RET-related IPRs or licensing on concessionary terms. The *TIR 2011* shows that in several cases developed-country institutions have been involved in bringing developing-country partners together for this sort of cooperation. The benefits of such collaboration are straightforward: it hastens the wide dissemination of RETs among developing countries along with all the commensurate benefits associated with it.

RETs can power development and a greener catch-up process

Developing countries will face different problems in RETs promotion, production and innovation, depending on their respective starting points. Nevertheless, for all developing countries, RETs present real opportunities for reducing energy poverty, and the right policies could influence the extent of benefits that could be derived from RETs use, adaptation and dissemination. This *TIR* presents five relevant findings from ongoing national and regional experiences with technology and innovation capacity-building of relevance to RETs.

First, the success of a number of emerging economies in developing technological capabilities over time is largely attributable to the role of national governments in providing strategic, concerted support for the use of RETs. However, the experiences of industrialized countries or the larger developing countries such as China and India may not be replicable in other developing countries due to their less favourable circumstances. The Report also highlights some of the policy incentives that need to be approached with caution. Of special note are those related to carbon taxes, but these may not be relevant or useful for many developing countries.

Second, developing countries should consider different kinds of energy regimes that give priority to the deployment of REs most suited to their specific contexts, while ensuring that conventional energy sources are not subsidized extensively.

Third, success in eliminating, or at least reducing, energy poverty through the use of RETs does not necessarily require large-scale projects with huge investments. Smaller initiatives have been highly successful as off-grid solutions to rural electricity, and offer considerable potential for replication.

Fourth, creating an integrated innovation policy framework of the kind outlined in this Report should not be viewed as a daunting exercise. In the developing-country context, a few incentives can go a long way towards achieving significant results. Further, many countries may already be providing several of the policy incentives discussed in the Report. The emphasis in such cases needs to be on enhanced coordination to reach targets in RETs use, promotion and innovation.

Fifth, countries will need to experiment with different policy combinations, and this learning process could have positive impacts on the co-evolution of institutional frameworks for RETs.

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National governments in developing countries have a pivotal role to play in combining conventional sources of energy with RETs. Proactive government interventions will need the support of the international community to benefit from the full potential that RETs offer for alleviating (and eventually eliminating) energy poverty, but also simultaneously promote climate-friendly solutions on a global scale. Forging strong partnerships with the international community could also lead to the widespread dissemination of environmentally sustainable technologies worldwide, resulting in enhanced economic development and greater opportunities for large segments of populations that have been left behind in the process of globalization.

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Secretary-General of the UNCTAD

Geneva, October 2011

NOTES

1 See: http://unfccc.int/press/fact_sheets/items/4987.php.

2 Since the beginning of the eighteenth century, production and consumption patterns in the now developed countries have been dependent on energy provided successively by coal, oil and gas, and to a lesser extent by nuclear fission. The dramatic increases in the use of fossil energy (which, at current levels of annual consumption, is estimated to represent between one and two million years of accumulation) have enabled massive increases in productivity in both farming and manufacturing (Girardet and Mendoça, 2009). Such productivity growth has made possible a roughly tenfold increase in the global population over the past three centuries, accompanied by significant, if unevenly distributed, improvements in living standards.

3 Recent estimates suggest that developing countries will continue to suffer 75–80 per cent of all environmental damages caused by climate change (World Bank, 2010).

4 An innovation system is defined as a network of economic and non-economic actors and their interactions, which are critical for interactive learning and application of knowledge to the creation of new products, processes and organizational forms, among others.

5 It is estimated that electricity supply systems can easily handle up to 20 per cent of RE, and even more if systems are designed with some adjustments in intermittency.

6 Krohn, Morthorst and Awerbuch (2009) and UN/DESA (2009).

7 "Clean technologies" or "clean energies" cover a much broader range than RETs, and include clean coal, for example.

8 Broadly, the processes that fall under *adaptation* are those that seek to reduce/prevent the adverse impacts of ongoing and future climate change. These include actions, allocation of capital, processes and changes in the formal policy environment, as well as the establishment of informal structures, social practices and codes of conduct. *Mitigation* of climate change, on the other hand, seeks to prevent further global warming by reducing the sources of climate change, such as greenhouse gas (GHG) emissions.

9 The UNFCCC estimates cover only power generation, which includes carbon capture and storage (CCS), nuclear and large-scale hydro.

10 Access to environmentally sound technologies (which includes RETs) and related technology transfer has become a cornerstone of the draft UNFCCC (see Articles 4.5 and 4.7 of the draft Convention).

REFERENCES

Girardet H and Mendoça M (2009). *A Renewable World: Energy, Ecology, Equality.* A report for the World Future Council. Totnes, Devon, Green Books.

IEA (2000). *Energy Technology Perspectives 2000*. Paris, OECD/IEA.

IEA (2009). *World Energy Outlook 2009*. Paris, OECD/IEA.

IEA (2010). *World Energy Outlook 2010*. Paris, OECD/IEA.

Krohn S, Morthorst P-E and Awerbuch S (2009). The Economics of Wind Energy, European Wind Energy Association.

REN21 (2010). *Renewables 2010: Global Status Report*. Paris, REN21 Secretariat.

REN21 (2011). *Renewables 2011: Global Status Report*. Paris, REN21 Secretariat.

UN/DESA (2009). A Global Green New Deal for Climate, Energy, and Development. New York, United Nations.

UNEP and Bloomberg (2011). *Global Trends in Renewable Energy Investment 2011*. *Analysis of Trends and Issues in the Financing of Renewable Energy.* United Nations Environment Programme. Available at: www.fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2011.

UNCTAD (2011). *Technology and Innovation Report 2011: Powering Development with Renewable Energy Technologies.* United Nations publication. New York and Geneva, United Nations.

World Bank (2010). *Africa's Infrastructure: A Time for Transformation*. Washington, DC, World Bank.