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Green and renewable technologies as energy solutions for rural development

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Executive summary

Access to electricity and modern energy sources is a basic requirement for achieving and sustaining higher living standards. Yet 1.6 billion people lack such access, and more than half of all people living in developing countries rely on traditional biomass to meet their basic energy needs. Despite the challenges of providing modern energy to poor remote areas, new technological developments, innovative project design, climate change mitigation requirements and new opportunities for policy synergies offer strategic options to meet the objective of providing universal access to energy services for carbon-efficient rural poverty reduction. Renewable energy technologies (RETs) such as solar, wind, biofuels and mini-hydro can conveniently be utilized to provide electricity in small stand-alone systems, not connected to national electric grids. They can constitute economical and reliable options to deliver energy to remote rural areas.

The use of RETs in rural poverty eradication strategies provides an exemplary win–win result for economic growth, job and income generation, and environmental sustainability. Scaled-up deployment of RETs in rural areas can enhance export competitiveness and open new opportunities for South–South cooperation, and increased trade and investment. This issues paper describes some of these opportunities and discusses policies and measures to successfully harness RETs for sustainable rural development.

Introduction

1. The UNCTAD Trade and Development Board, at its forty-seventh executive session, held on 30 June 2009, approved “Green and renewable technologies as energy solutions for rural development”, as the topic for a single-year expert meeting, which will be held from 9 to 11 February 2010. The findings and recommendations of this expert meeting will be reported to the Investment, Enterprise and Development Commission and the Trade and Development Commission when they meet in April and May 2010, respectively.

2. Commitments to improve access to reliable and affordable energy services, in particular to increase the share of renewable sources of energy in the global energy supply, have been repeatedly made by governments at the international level, most notably at the World Summit on Sustainable Development (WSSD) held in 2002, the World Summit (2005) and UNCTAD XII (2008).[1]

I. The nexus between access to energy and rural poverty

3. Access to electricity and other modern sources of energy is a basic requirement for the achievement of economic growth and human development objectives. Of course, while such access alone is not sufficient to ensure human development, the achievement of higher standards of living in the absence of affordable and predictable energy supply is virtually impossible. Yet an estimated 1.6 billion people lack access to modern energy, and 2.5 billion–3 billion people rely on traditional biomass for most of their energy needs (heating and cooking). The majority of electricity-deprived poor people live in sub-Saharan African and South Asia (table 1), and, at current rates of electrification, the number of people using traditional biomass is expected to remain constant or could even increase to 2.7 billion by 2030 because of population growth (IEA, 2006). In some sub-Saharan countries, less than 5 per cent of rural populations have access to electricity: (a) Ethiopia (2 per cent); (b) Malawi, Mali and Uganda (2.5 per cent); and (c) Kenya and Zambia (3.5 per cent) (World Bank African Development Indicators, 2006).

Table 1
Access to electricity, by urban and rural areas
(per cent)

Region	Total	Urban	Rural
Africa	37.8	67.9	19.0
North Africa	95.5	98.7	91.8
Sub-Saharan Africa	25.9	58.3	8.0
Developing Asia	72.8	86.4	65.1
China and East Asia	88.5	94.9	84.0
South Asia	51.8	69.7	44.7
Latin America	90.0	98.0	65.6
Middle East[a]	78.1	86.7	61.8
Developing countries	68.3	85.2	56.4
Transition economies[a] and OECD[b] countries	99.5	100	98.1
World total	75.6	90.4	61.7

[a] The regional designations follow those used by the International Energy Agency (IEA).
[b] Organization for Economic Cooperation and Development.
Source: IEA 2006: table B1.

[1] See, for instance, paragraphs 83 and 98 of the Accra Accord.

4. Moreover, it is possible that the number of people who lack access to electricity could increase over the coming months because of the employment and income effects of the global economic recession and the surge in food prices. The World Bank estimates that, as a result of the food, financial and economic crises, an additional 89 million people will be living in extreme poverty (on less than $1.25 a day) by the end of 2010. This is compounded by the steep fluctuations in the price of fuels. At the same time, more constrained domestic budgets in developing countries and a consequent reduction of public spending for the expansion of national electrical infrastructure and capacity could delay or even reverse progress in rates of electrification (IEA, 2009).

5. Such "energy poverty" has a serious impact on living standards and productivity, and a direct impact on rural poverty, and is therefore a central aspect in strategies for the reduction of rural poverty. Some of the main problems associated with the lack of access to modern energy include:

(a) Access to modern energy directly influences living standards (e.g. availability of lighting);

(b) It also bears on access to improved social services, such as water and sanitation, health (e.g. refrigeration for medicines and vaccines, and power for equipment), telecommunications and education (e.g. lighting for studying and reading, access to television and computers, etc.). In addition, access to modern energy sources can contribute to improved school enrolment rates (particularly for girls, as the burden on girls of collecting fuel wood is reduced), access to information and communication technologies (telephony and Internet), and an increased ability of rural communities to retain doctors, teachers and other professionals as it improves living standards;

(c) Access to modern energy can also directly influence the competitiveness of productive activities or even the availability of such activities in rural areas. Agricultural productivity, for instance, can be enhanced (i.e. through irrigation), value can be added to existing productive activities (e.g. grinding, milling, refrigeration and food processing), and new sources of income can be developed (e.g. brick-making, sewing, joinery and the manufacturing of handcrafts). This can also strengthen export supply capacity and competitiveness, and offer opportunities for South–South cooperation;

(d) In the absence of modern sources of energy, poor people overwhelmingly rely on the burning of traditional biomass to meet their most basic energy needs. In some sub-Saharan African countries, biomass provides 90 per cent of all energy consumed. Some of the major problems associated with the utilization of traditional biomass include:

(i) First, there are health hazards because of the pollutants emitted during biomass combustion (e.g. carbon monoxide, small particles and benzene). The high indoor concentration of such pollutants results in a higher prevalence of respiratory diseases, obstetrical problems, eye infections and blindness, among others (IEA, 2002). Indoor air pollution could cause as much as 2 million deaths every year (WHO, 2000: 1086) – almost three times the death toll resulting from urban air pollution. Since women and children spend more time indoors, they are more exposed to such risks. The World Health Organization (WHO) estimates that indoor air pollution ranks fourth in terms of the risk factors that contribute to disease and death in developing countries.

(ii) Second, reliance on biomass by communities and households results in the wasteful utilization of resources, chiefly time spent gathering fuel (small wood or charcoal). The need to collect wood is thought to deprive girls (who usually collect the wood) from time spent in school. The IEA reports that women in Uganda walk up to 11 km daily to gather fuel wood (IEA, 2006: 430). It is estimated that in northern India, two to seven hours are spent daily on the collection of biomass for fuel (IEA, 2002). Moreover, inefficient burning stoves unnecessarily increase cooking time;

(iii) Another associated problem concerns the unsustainable use of forests through the collection of wood. There seems to be a strong correlation between deforestation and wood fuel for burning. Therefore, the introduction of modern sources of energy can reduce this form of environmental degradation. It should be noted, however, that the effects on deforestation of biomass utilization by rural communities are very location-specific. While wood burning is not always a primary cause of tree-cutting (as women carry mostly twigs), it can exacerbate other existing environmental problems. However, in some instances (e.g. in Africa), fuel wood collection does constitute one of the causes of tropical deforestation (Modi *et al.*, 2006:30).

(iv) Society as a whole bears a heavy economic burden for these inefficiencies. For example, in India, the opportunity cost of time lost in gathering fuel, working days lost due to eye infections and respiratory diseases and the costs of medicines were estimated at 300 billion rupees, or close to 0.7 per cent of India's gross domestic product in 2006;

(v) Some of the particulates from biomass combustion, called black carbon, are now recognized as an important source of climate change, together with other particulates from burning fossil fuels and biofuels.

(e) Finally, access to modern energy contributes to gender equality. Since in many cultures and societies women are primarily responsible for the gathering of fuel wood, the time saved can be devoted to the pursuit of productive work, education and other economic and social activities.

6. Because of its centrality to the achievement of human development, access to energy has been defined as the "missing Millennium Development Goal (MDG)".[2] In fact, the implementation of electrification programmes over the past three decades has enabled the accumulation of enough empirical evidence to confirm the strong correlation between energy services, poverty reduction, and indeed the achievement of all the MDGs (Modi *et al.*, 2006). Major improvements in the quality and quantity of energy services in developing countries' rural areas can be done in two principal ways:

(a) Increasing access to modern energy for domestic use – essentially increasing access to technologies which use new fuels or better use of traditional fuels in cleaner, safer and more environmentally sound ways; and

(b) Increasing access to electricity, (for lighting and to power household and commercial appliances), and to mechanical energy (e.g. to operate agricultural and food processing equipment (e.g. grinding), to carry out supplementary irrigation (e.g. from water pumping), etc.)).

7. Stand-alone RET solutions can offer an ideal and very strategic match in that respect.

[2] See, for instance, "Energy missing Millennium goal – U.N. climate chief". *Reuters*. 21 January 2009 (citing Rajendra Pachauri, IPCC chairperson); accessible at: http://www.reuters.com/article/homepageCrisis/idUSDEL270134._CH_.2400.

II. Benefits of deploying RETs for rural development

8. In addition to the general welfare improvements of rural electrification, benefits can accrue if electrification is based on RETs. First, they are optimally suited for individual units, not connected to national electricity grids, and hence ideal for remote areas. RETs use energy sources that do not deplete the Earth's natural resources and do not create added waste products (table 2).[3] In particular, the decentralized nature of green and new renewable energy technologies (GRETs) allows them to be locally designed to match the specific needs of different rural communities (Havet *et al.*, 2009).

Table 2
Green and renewable energy sources and corresponding GRETs

	GRETs	
Energy source	**Energy for domestic use**	**Electricity**
Elemental renewables		
Solar	Solar pump, solar cooker	Solar-PV
Water		Micro- and pico-hydroelectric generating plant
Wind	Wind-powered pump	Wind turbine generator
Wave/tidal		
Geothermal		Geothermal generating plant
Biological renewables		
Energy crops	Biogas digester	Biomass generating plant
Standard crops (and by-products, including agricultural waste)		
Forestry and forestry by-products	Improved cookstoves	
Animal by-products		

Source: Adapted from Renewable Energy Association 2009.

9. Second, the choice of renewable energies for rural electrification contributes to the diversification of national energy mixes, thereby contributing to developing countries' energy security. While under certain circumstances, projects utilizing diesel generators or diesel-RET hybrids may be more appropriate, the choice of renewables has the advantage of limiting an increase in fossil fuel imports. This is an important consideration in times of economic crisis, tighter national budgets and volatile oil prices. Finally, at the household level, access to electricity, particularly if based on RETs, can also improve the energy security of families, as they are no longer subject to oil price fluctuations[4] and to what can be high costs of transportation and delivery of fuel. This of course is only valid where RETs have a comparative advantage over fossil fuels in terms of resources and costs. If market externalities are accounted for, then the comparative advantage may grow. Also, costs can be reduced through technological improvement and appropriate subsidies.

[3] Biodigesters, for instance, can make a significant contribution to sound management and productive use of agricultural waste and residues as well as improved sanitation. For instance, the connection of household toilets to biogas plants in Nepal has significantly improved hygiene through effective management of excreta and wastewater (Ashden Awards, 2005).

[4] The World Bank (2006) notes that, during peaks in oil prices, poverty increases significantly: it estimates that during the price increase of oil in 2006, poverty increased by as much as 2 per cent in 20 developing countries.

10. Finally, the choice of renewables for rural electrification offers positive synergies with national, regional and global climate change mitigation policies. RETs deployment is a concrete mitigation action, since it avoids additional emissions from fossil fuel energy generation, and may even reduce current emissions if it results in fuel switching. Renewable fuels-based electrification programmes enable developing countries to contribute to global mitigation efforts in nationally appropriate ways. They are also an important adaptation measure, since access to this form of energy is likely to enhance the economic and social resilience of rural communities, whose livelihoods could be affected by climate change. By improving farmers' access to information and knowledge, and by increasing farm productivity, rural electrification programmes can safeguard their livelihoods. The extent to which electrification policies are able to harness potential synergies with climate mitigation and adaptation objectives depends on how well electrification policies are integrated into national development and climate policies.

III. Integrating deployment of RETs in rural poverty reduction strategies

11. There are multiple economic, social and environmental benefits of using RETs to provide access to modern energy in rural areas (UNCATD, 2010). These direct and indirect benefits justify governments approaching this objective as a full component of an integrated development policy package, and not as a stand-alone element of investments in infrastructure. By creating an enabling environment for the emergence of income-generating or income-improving activities, access to energy projects can directly contribute to poverty eradication policies and should therefore be seen as a strategic tool in poverty reduction policies. RET policies therefore need to be embedded within rural development strategies to ensure they are demand-driven, based upon the needs of the rural poor and specific to local context and potential income-generating activities.

12. In fact, renewable energy-based rural electrification projects may unleash the productive – and hence income-generation – capacity of rural communities. This entails approaching access to energy in an integrated manner, seeking to exploit "pockets of opportunities" (Reiche, *et al.*, 2000), that is, the identification of business opportunities at all levels, the creation of enterprises, cooperatives and artisanal businesses and the insertion of electrification investments within broader policy objectives (e.g. irrigation, product processing and diversification, and employment and income generation). It also entails exploiting policy synergies, for instance, for the deployment of RET in public buildings and facilities (e.g. schools, dispensaries and water pumping and purification).

Box 1. Integrated approach to rural energy projects

An illustration of this integrated approach can be found, for instance, in the installation of multifunctional energy platforms in West Africa (provision of mainly mechanical power for productive industries using very simple technologies).[5] The developmental and environmental potential of these platforms is even more strategic if they are based on RETs such as hydropower or locally produced biofuels. Another illustration of this approach is Desi Power's EmPower Programme (see below).

[5] See, for instance, http://www.pnud.bf/DOCS/Plate-forme_FRA.pdf.

13. The use of energy for productive uses (in addition to domestic uses) can significantly increase overall energy consumption, improving investment security because of the assurance of a critical mass of regular users. Moreover, the enhancement of income opportunities allows end-users to secure improved incomes, which in turn improves their capacity to pay for energy services. Energy use for productive activities can increase productivity, boost competitiveness and enhance developing countries' trade opportunities. In addition to improving profitability and reducing investment risks, this increases the social benefits of investment and enhances the medium to long-term sustainability of projects.

14. When linked to agriculture in a rural context, RETs offer many opportunities to improve the income and food security of farming communities. For instance, if projects include capacity-building and access to telecommunications (mobile phones, Internet, radio, etc.), they can enhance farmers' knowledge about prices and markets, thereby possibly raising their trade capacity. If associated to trade-related capacity-building for sustainable agricultural production, RETs can open new and more remunerative trading opportunities. Organic agriculture, for instance, offers indeed higher incomes for developing country farmers and a range of environmental, health and social benefits. Agricultural waste and animal manure can be used to produce biogas and the slurry makes an excellent organic fertilizer. The same organic matter can be used twice. While many combinations of this type exist in Asia, there is still ample scope to generalize these systems in the developing world.[6]

15. In addition to the benefits which directly arise from access to energy for income-generating activities, renewable energy sources also offer more ample employment generation opportunities. First, local firms are required for the installation, maintenance, repair and recycling of RET products and systems. The presence of these services firms generates local employment and is indeed a requisite for the penetration of these technologies in remote rural areas as well as for the long-term sustainability of projects. If successful, rural energy companies can provide their services throughout the country or even within regions, thereby creating new South–South trading and investment opportunities.

Box 2. RETs and employment generation

There are indeed several examples of projects based on RETs that have fostered the creation of hundreds, sometimes thousands, of rural enterprises that supply electricity and ensure the maintenance of equipment. For example, in Cambodia, 600–1,000 rural small and medium-sized enterprises supply electricity to some 60,000 households (World Bank, 2008). In Nepal, a programme that deployed 170,000 biogas plants in recent years has led to the creation of 55 construction companies, 15 biogas appliances manufacturers and 80 finance institutions, creating about 11,000 direct jobs in the biogas sector and another 65,000 jobs through spin-off (Ashden Awards, 2005).

16. Second, the manufacturing itself of RET products offers opportunities for employment generation, trade, the creation of local industrial capacity, local innovation and

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[6] See, for instance, http://www.unep-unctad.org/CBTF/events/kampala5/day1a/6-Making%20a%20link%20between%20biogas%20and%20organic%20agriculture%20Uwize.pdf.

technology dissemination. By adding local content to projects and by adapting RETs to local conditions, it is possible for developing country first-mover manufacturers to benefit from domestic, regional and international demand for RET products and services. An important lesson for the sustainability of rural energy projects is indeed that efforts should be made to maximize local content and local knowledge in order to achieve the most positive results. The greater the local content of RET systems and the stronger the involvement of local enterprises in the energy industry's auxiliary services, the greater will the spillover effects into the national industrial capacity be (UNCTAD, 2009a).

17. For instance, biogas digesters utilize simple technology and can therefore be manufactured locally. In China, for example, it is estimated that 1 million biogas digesters are produced annually, and the market is set to continue growing, as the Government provides subsidies and has set targets to increase the number of digesters. Similar trends are also evident in India and Nepal (REN21, 2007:33). Another illustration concerns the opportunities related to the manufacture of safer and more efficient cooking stoves for dissemination in the African continent. Similarities among developing countries provide scope for the South–South transfer of knowledge and increased trade in components (UNCTAD, 2010).

Box 3. Indoor air pollution and local production

Stove improvements in developing countries are not a new phenomenon – efforts to reduce indoor pollution and improve cooking efficiency have been ongoing for over 40 years. A key lesson from the early programmes was the importance of localizing the manufacture of stoves at affordable prices (Barnes *et al.,* 1994; Ergeneman 2003). This lesson was clearly taken onboard by the Government of Eritrea, when it initiated the Dissemination of Improved Stoves Program (DISP) in 1996.

Under DISP, the Energy Research and Training Centre (ERTC) of the Ministry of Energy and Mines was responsible for the development and dissemination of an improved version of the traditional mogogo clay stoves. The inefficiency of these stoves exacerbates the problem of deforestation. It is also difficult to light, produces considerable smoke and endangers children because it stands at floor level. The improved stove combines some of the advantages of the traditional mogogo design with efficiency and safety modifications. It is estimated the improved stoves reduce household consumption of biomass by more than 50 per cent. The reduced deforestation has made the project eligible for funding through the Clean Development Mechanism (CDM), which could have a significant impact on further implementation of the scheme (Climat Mundi, 2009).

The materials required to construct the improved stoves are all produced in Eritrea. Almost all stove parts can be made locally. The total cost of a stove is roughly $20 and non-local materials for stoves are subsidized through DISP, usually amounting to 85 per cent of total cost (Ergeneman 2003). To promote this technology, ERTC has been providing training to rural women on how to build the stoves themselves, and hire them as trainers to train others. (Ashden Awards 2003).

18. Finally, the experience gained in rural energy access projects is likely to generate knowledge, entrepreneurial expertise and manufacturing capacity in renewable energy-related industries, which opens opportunities for international trade and cooperation. RET products and services will certainly be a fast-growing economic sector in global trade for years to come.

IV. Policy tools

19. Among the factors that influence the uptake of RET in rural energy projects, the cost of electricity for users and the profitability of energy services are of major importance. Policymakers managing rural electrification programmes must find a balance between the affordability of energy for users and the profitability of the service for private operators. A major risk in this respect is that, even when connected to the national grid or local mini-grids, households continue to rely, either partially or entirely, on traditional biomass for their energy consumption. A related risk is that the lack of awareness and of skills triggers the non-utilization of RET units. Both outcomes would limit the environmental or social benefits of public investments, or undermine the profitability of service providers.

20. To improve the affordability of electricity, ensure effective access and yet guarantee the profitability of the scheme, governments can act on two fronts: the demand side (consumers) and the supply side (power generation).

21. As far as affordability is concerned, governments can act to ensure affordable upfront installation costs as well as affordable monthly charges. Subsidies are a classic, sometimes indispensable, instrument to help lower both initial and operating costs of electricity. Governments may, for instance, envisage the provision of financial assistance to reduce the burden of connection or installation costs (i.e. subsidize partly or entirely the initial installation or connection costs, facilitate access to credit, or ease payment conditions, for instance by accepting payments over a prolonged period). In addition, governments may subsidize electricity costs over a given period to ensure that the poorest households have access to a basic level of services. One tool in that respect is the use of a differentiated tariff structures: that is, the first 50–100 kWh consumed may be sold below cost and subsequent consumption charged at a higher rate. Since poor households tend to consume little electricity, they would likely benefit from overall reduced rates, or a “lifeline rate”.

22. Nonetheless, there are many risks associated with the utilization of subsidies. Typically, they might be badly targeted, and hence hardly reach the intended neediest households. Their phasing out is always a delicate exercise if projects have not resulted in sufficient local income generation opportunities. Moreover, poorly targeted subsidies can distort markets. This is the case of subsidies for fossil fuels, which make the deployment of RETs less advantageous, or subsidies for certain RETs, which distort competition amongst RET options. Subsidies that lower the price of energy may encourage wasteful and inefficient energy consumption. Finally, when handed directly to energy supplying firms, subsidies can discourage innovation, technological upgrading and cost effectiveness, and may even compromise the overall quality of service. If perverse subsidies are not removed, subsidies for RETs may be needed to level the playing field and encourage their utilization.

23. In addition to subsidies, one tool to improve the affordability of RET systems is to provide the poorest households with access to financial services. For instance, the banking sector, when present in rural areas, does not always offer instruments adapted to the needs of rural users. In the absence of credit markets, households cannot borrow to pay the connection charge. Microfinance (e.g. in Ethiopia, Bangladesh and Sri Lanka), extended or facilitated repayment periods (e.g. in Morocco and Senegal) and microleasing can

significantly increase the consumer base for energy providers. Often, access to microcredit is a fundamental factor in the successful dissemination of RETs in rural areas, as the Grameen Bank and BRAC examples in Bangladesh illustrate. Expanding the availability of microfinance and reaching remote users often entails supporting community organizations and cooperatives, rural banks and non-governmental organizations.

24. As far as profitability is concerned, the key is to ensure a thriving energy market, that is, private sector operators must be in a position to continue offering energy services even after grants or subsidies are discontinued. By supporting start-up costs and combining access to energy investments to income-generating activities, governments can greatly improve the commercial viability of investments. However, there are additional and supplementary policy instruments available to improve profitability. One such instrument is to utilize public procurement (purchase of a large quantity of power-generating units) as a means of reducing capital outlay. An additional possibility is to lower capital costs by exempting off-grid RET equipment from import tariffs and other taxes, but the effectiveness of this option depends on the restrictiveness of import duties as a barrier in accessing RET products. Finally, another tool to enhance profitability is to explore innovative service delivery models. The development of business models can be fostered through specific regulatory frameworks (Martinot and Reiche, 2000). National energy regulation is indeed crucial in promoting private sector investments, ensuring greater penetration of renewable energy sources and greater cooperation among system operators with the aim of improving the security of energy supply, demand and transit. There are several emerging service delivery models that offer ground for experimentation and learning (Reiche, *et al.*, 2000).

25. Another possibility for improving the profitability of investments is to stimulate demand and thereby increase the utilization of energy by consumers. This comprises chiefly capacity-building efforts and support to stimulate energy utilization in productive activities. One of the clearest lessons from the implementation of electrification projects over the past decades is that local stakeholders must be closely involved in the design and implementation of projects to ensure an adequate ownership of the investments. Since the pattern of energy consumption has major implications with regard to the benefits that can be derived from electrification, consumer education must also be part of investment packages. It entails overcoming technology resistance, awareness-raising, training of local technicians, technology demonstration, and upstream involvement of the population to increase local ownership.

26. Last but not least, it is possible to bundle together electrification projects with other public services such as water, financial services and telecommunications. Bundling several services together helps reduce the high transaction costs from servicing a myriad of dispersed end-users (e.g. information and marketing, installation, fee collection, maintenance, after-sales customer services and non-payment interventions). It also facilitates government regulation and oversight, and tremendously enhances the welfare and developmental impacts of projects. A study focusing on middle-income economies noted that the addition of a fourth service provides a marginal benefit about seven times greater than the addition of a second service (Reiche, *et al.*, 2000).

27. However, fully exploiting the benefits of bundling rural services depends on government’s ability to identify policy synergies (e.g. agriculture, energy, climate mitigation and adaptation, rural development, innovation and investment policies). This requires strong institutional capacity and regulatory frameworks, which are often lacking in many developing countries. A useful instrument for promoting policy coordination is to adopt a multisectoral approach to an electrification policy – that is, to coordinate action among public agencies and ministries to identify possibilities for joint investments, synergies and service bundling.

Box 4. Exploiting policy synergies

An interesting attempt is CIMES/RP,[7] a mechanism created by Senegal's Rural Electrification Agency, which aims at facilitating access to energy services in rural areas, including by identifying possibilities of supporting or exploiting synergies with other sectors (e.g. water, education, health, telecommunications, gender, agriculture and the environment). It makes a direct contribution to the identification of multisectoral energy programmes, and hence for electrification for productive uses. CIMES also supports a wide range of stakeholders to enhance their awareness about the linkages between energy and development, and assists in the identification of energy components in poverty reduction strategies.[8]

V. Finance

28. A major parameter to gauge the success of electrification programmes is whether or not initial investments have generated a developmental spiral that promotes self-sustainability beyond implementation time frames. In this sense, the long-term viability of projects requires all stakeholders to draw sufficient benefits from investments, which highlights the strategic nature of an integrated approach to access to energy. Where circumstances are favourable, the private sector can penetrate markets and achieve noticeable expansion without much support through subsidies. Examples of fully commercial deployment of RETs in rural areas include solar PV systems in China and Kenya, some PV companies in India, micro-wind systems in China and Mongolia, and pico-hydro projects in the Lao People's Democratic Republic and Viet Nam (World Bank, 2008: 11).

29. In most cases, nonetheless, public intervention is required to increase the attractiveness of investments in RETs in rural areas. Installation costs make up the bulk of costs related to RETs, although the price of these technologies is quickly falling as they become more mature and more widely used. As a matter of fact, the more generalized the global efforts to deploy RETs, the greater the demand will be for these technologies, allowing firms to achieve economies of scale and hence reduce production costs.[9] By supporting start-up costs, and sometimes electricity rates, governments can greatly improve the commercial viability and sustainability of investments. However, a weak private sector, firms' reduced cash flows, the credit crunch and constrained government budgets could make it difficult to mobilize sufficient finance over the short-to-medium term.

[7] *Comité intersectoriel de mise en œuvre des synergies entre le secteur de l'energie et les autres secteurs stratégiques pour la réduction de la pauvreté.*

[8] Similar structures exist in some other West African countries, and are supported by the White Paper for a Regional Policy in order to achieve the Millennium Development Goals of the Economic Community of West African States (ECOWAS). See: http://www.energyandenvironment.undp.org/undp/indexAction.cfm?module=Library&action=GetFile&DocumentAttachmentID=1675.

[9] Research on wind energy equipment, for instance, has found that a doubling of production triggered reductions in unit costs as great as 20 per cent. Junginger, *et al.*, 2005.

30. One innovative strategy that could be explored is mobilizing multiple sources of finance, such as public finance, bilateral donors and international development institutions (both governmental and non-governmental), equity from local partners – including investors and cooperatives – global funds related to climate change mitigation and RET deployment, and commercial banks, as well as consumers (who should own projects and generate finance). The volume of resources involved means these various sources of finance must coordinate their actions and exploit all possible partnerships and synergies. This highlights the scope that public–private partnerships can play in infrastructural development. This is already happening, although there are still tremendous opportunities to be tapped.

Box 5. Multiple source financing

The DESI Power EmPower Partnership Programme is an initiative that seeks social investment for a decentralized, biomass-driven electrification programme in the State of Bihar in rural India. The programme creates 100-kW biomass-gasification power plants, each expected to create at least 50 direct and indirect jobs in each village.

The programme has used multiple sources of up-front funding. A governmental subsidy and the selling of CO_2 emissions savings (shown as a likely source of capital for the villagers who have no capital of their own) are used for "leveraging" capital by convincing ethical investors to provide the external equity or loan. Discussions with commercial and development banks indicate that they would be prepared to consider 50–60 per cent of the project cost as a loan if the other funds were assured. The breakdown of principal funding sources is as follows:

Sources of funds, % of total

External equity	Local equity	Government subsidy	CERs	Grant for capacity-building	Bank loan
40–70	2–5	10-12	0–30	8–13	15–30

31. While lack of finance to cover market studies, capital costs and capacity-building is a major stumbling block for the multiplication of RET-based rural projects, one element that also deserves attention is finance to foster the emergence of energy enterprises. These enterprises can and probably should lead investments, raise finance, and maintain and operate RET equipment. They are also responsible for a large share of the employment potential of RET investments in rural areas. For instance, the United Nations Environment Programme's African Rural Energy Enterprise Development Initiative, supported by the United Nations Foundation, works with African non-governmental organizations and development organizations, helping them to identify potential energy projects and providing entrepreneurs with business support services (business start-up support, planning, management structuring and financial planning).

32. There are, in addition, several multilateral and bilateral programmes of cooperation that aim at increasing the utilization of renewable sources of energy in the context of

climate change mitigation. Examples include (a) the Global Environmental Facility's Trust Fund, under its Climate Change[10] focal area; (b) the large volumes of concessionary lending for rural electrification managed by the World Bank; (c) the World Bank's specific energy initiatives (such as the Lighting Africa initiative)[11]; (d) The World Bank's Climate Investment Funds and its related Clean Technology and Strategic Climate Funds; and (e) a myriad of bilateral donor initiatives.[12]

33. Finally, an extremely timely and useful positive synergy can be found in the CDM under the Kyoto Protocol, which is increasingly seen as a useful and potentially large source of finance. Development and deployment of renewables constitute the lion's share of registered CDM projects and includes a sizeable number of registered and validated projects involving fuel switching and the deployment of RETs, some of which concern rural communities.[13] Related to this is the possibility of having recourse to global carbon markets. For example, in 2008, two new World Bank projects in Bangladesh were approved for 1.3 million SHS to be installed by Grameen Shakti and Infrastructure Development Company Limited. These projects are among the first to incorporate off-grid PV carbon finance (REN21, 2009). Financial opportunities created by the CDM for RET-based services would amply justify government support for RET deployment (as opposed to energy subsidies, irrespective of technology used).

34. There are, nevertheless, many obstacles to fully exploiting the potential of the CDM for small-scale projects, such as those relating to RET-based electrification of rural areas. Commonly cited barriers include high transaction and associated costs (registration, validation and verification), which are too high given the size of the projects and the fact that the small volumes of avoided or reduced CO_2 per household might be unattractive for project developers and CDM investors. Another challenge regarding the utilization of CDM is channelling the distribution of investments much more to rural areas, particularly in the poorer developing countries such as those of Africa.[14]

35. Producers of components or RET systems, including in other developing countries such as China and India, may provide assistance and funding in developing the RET market in rural areas. Integrated support packages in this regard might include technical advice, funding, building up maintenance capacity, training, assistance for developing value-generating activities and harnessing spin-off effects. This can result in an array of opportunities for South–South cooperation and investment (UNCTAD, 2010).

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[10] See: http://www.gefweb.org/projects/Focal_Areas/climate/climate.html.

[11] See: http://www.lightingafrica.org/.

[12] See, for instance, the International Climate Initiative of the German Government. With respect to the mobilization of global resources for clean energy deployment, the G-8 energy ministers have accepted a proposal to launch an expert-level working group with the participation of G-8 countries and other countries, particularly from the African continent, as well as institutions that may wish to contribute to enabling entrepreneurs to build clean energy businesses serving rural and urban Africa. See the Joint Statement by the G-8 Energy Ministers, the European Commissioner and the Energy Ministers of Algeria, Australia, Brazil, China, Egypt, India, Indonesia, the Republic of Korea, the Libyan Arab Jamahiriya, Mexico, Nigeria, Rwanda, Saudi Arabia, South Africa and Turkey at the G-8 Energy Ministers meeting in Rome, 24-25 May, available at: http://www.g8energy2009.it/pdf/Session_II_III_EC.pdf .

[13] RET-focused CDM projects have accounted for almost two thirds of all implemented CDM projects in recent years. The lion's share of these projects was however concentrated on four countries only: China, India, Brazil and Mexico (in descending order), accounting for three quarters of all CDM projects (UNCTAD, 2009b).

[14] Ibid.

VI. Technology

36. GRETs used to produce energy for domestic use tend to do so by exploiting new fuels or by using traditional fuels in new and improved ways. GRETs that generate electricity can do so as part of a stand-alone (or off-grid) system or they can be grid-based by way of connection to a mini-grid or the national grid.

37. Common GRET options for providing energy in rural areas use wind, solar, small-scale hydropower and biomass resources. Wind energy is used for pumping water and generating electricity. Solar-PV systems convert sunlight into electricity and solar heaters use sunlight to heat stored water. Small-scale hydropower plants are used to generate electricity and vary in size (micro, mini and pico). Most hydro systems are “run-of-river” schemes, which means the main energy-carrying medium is the natural flow of water. In these cases, dams are small and there is very little storage of water. As a result, they are cheaper and less demanding on the environment, but they are less efficient and heavily dependent on local hydrological patterns. Technologies that utilize biomass include improved cookstoves for efficient burning of traditional energy sources or biogas. Biogas can also be used in small plants to generate electricity (Alazraque-Cherni, 2008: 107; World Bank, 2004).

38. The appropriateness of technology choices depends on the availability of renewable resources, the load needed, the type of utilization, the cost effectiveness of various options and investment parameters. There is no “one-size-fits-all” solution. Neighbouring countries may adopt very different technologies due to differences in natural endowment, energy consumption, income level, willingness to pay, and other local conditions and expectations. Knowledge and skills, including those related to site survey, technology monitoring and assessment, are essential in the adoption and adaptation of technology to local climatic conditions and needs.

39. Although the use of GRETs as off-grid options for providing electricity services in rural areas is not new, the preferred approach of developing countries and donors to expanding electricity services has usually been expansion of the national grid (World Bank Independent Evaluations Group (IEG), 2008). However, grid extension has not always proven to be the most cost-effective means due to low population density and greater technical losses as transmission networks increase (Alliance for Rural Electrification, 2009). Off-grid systems served by GRETs are often the most appropriate option. It has been found that, for electricity generation, renewable energy is more economic than conventional generation for off-grid (less than 5 kW) applications.

40. However, a number of disincentives work against using off-grid GRETs. These include the limited influence of rural populations in political decision-making (Alliance for Rural Electrification, 2009). Second, off-grid systems rarely enjoy CDM support because they are small – and the transaction costs can outweigh any benefits from selling emissions reduction credits. So GRETs may look uncompetitive when compared to grid-based options (Kaundinya *et al.*, 2009). It has been argued that, for the deployment of RETs to be mainstreamed into power production, environmental externality costs need to be internalized for RETs to be competitive.

Box 6. Sample of applications for selected technologies

There are several illustrations of attractive technology options that have often been deployed in sub-Saharan Africa with clear benefits for income generation (e.g. linked to agricultural activities). These include:

(a) Wind pumps for irrigation, in South Africa (with over 100,000 wind pumps in operation) and Namibia (with close to 30,000 wind pumps);

(b) Small hydropower units for powering remote rural agro-processing factories in tea, coffee and forest industries in Kenya;

(c) Geothermal heat applications in remote rural horticultural concerns (flowers, vegetables and fruits) in Kenya;

(d) Co-generation in agro/forest industries in Côte d'Ivoire, Kenya, South Africa, Swaziland, Uganda and the United Republic of Tanzania;

(e) Solar water heaters, wind pumps for potable water and solar PV systems used in tourism infrastructure, particularly in Botswana, Kenya, Mauritius, Namibia, Seychelles, South Africa and the United Republic of Tanzania; and

(f) Use of wind turbines and solar-PV to expand telecommunications infrastructure (telecom bases) in Eastern Namibia

Source: Karekezi, *et al.*, 2007; GSMA Development Fund, 2007.

41. The most promising technologies that could offer large-scale deployment opportunities in rural areas include biomass, solar, wind and hydropower. Where customers are few and dispersed, and their main utilization of electricity is for domestic lighting, World Bank-sponsored projects have opted for individual systems, such as SHS or pico hydro systems, for small farms or homes that are located near a river. Some projects have used compact wind turbines in wind home systems. Where customers are concentrated, it can be more economical to connect them to a small grid or a centrally located generating system, typically based on RETs, on a diesel generator or on a diesel-renewable hybrid solution. Biomass-based power plants are also an option, though less common (World Bank, 2008:6).

42. To address the problem of intermittency, and in the absence of efficient and inexpensive storage technologies, GRETs are sometimes deployed in combination with diesel generators. Other types of hybrids are also possible, such as photovoltaic-wind hybrid systems, which take advantage of the varying availability of the solar and wind resources, allowing each renewable resource to supplement the other, and increasing the overall capacity factor.

43. A number of new technologies have recently attained greater commercial maturity. These include, for instance, off-grid solar PV products that are much smaller than the traditional 20–50 watt solar PV systems (sometimes called "pico-PV"). They are less

expensive and yet can provide a significant service to lower-income households (systems of 1–5 watts), particularly when coupled with advanced technologies such as ultra-low-power light-emitting diode lamps (LED). Products using this technology include solar torches, one-piece solar lanterns, or miniature solar-home-system kits that power one or two LED lamps and often also a radio or cell phone charger (REN21, 2009).

44. For GRETs to be a sustainable input into rural development, technology choice must be supported at a policy level and be context-specific (Murphy, 2001; Chaurey, 2004). Added to this is the need for ensuring local capabilities exist to supply, install, maintain and repair (manage) these innovative technologies. In order for technologies such as GRETs to be sustainable long-term solutions, the sale or giving of technology "hardware" must be complemented by development of local know-how related to that technology, the technology "software" (Ockwell *et al.*, 2009). Development of local technological capabilities – the "know-how" and "know-why" – is imperative. Experiences gained to date point to the critical importance of knowledge and skills, technological capabilities and supportive institutions, in the successful adoption, use, and adaptation of RETs to local needs and markets. Institutional development must be a key element of any programme to employ GRETs for rural development.

VII. Issues for discussion

45. In light of the potential carried by RETs for rural development and overall poverty reduction strategies, it is crucial that interested developing country governments have access to knowledge about best practices and synergies and current opportunities. To assist the compilation of such useful knowledge, some of the questions that experts attending UNCTAD's expert meeting may wish to discuss during include the following:

(a) What are the main problems associated with current patterns of energy production and consumption in rural areas? What are the distinct benefits of utilizing renewable energy sources for sustainable rural development?

(b) What are the main barriers to the promotion and deployment of green and renewable technologies in rural areas? What has been the role and impact of national policies and programmes to stimulate the deployment of renewables in rural areas, and what are the challenges?

(c) How can local participation be encouraged at the grassroots level during the design and implementation of electrification projects?

(d) How can private participation be encouraged to harness job and income-generation opportunities? What types of policy measures are most effective in fostering the mergence of energy-related manufacturing and services industries?

(e) What has been the impact of national policies related to trade, investment and technology on the access to, and development of, renewable technologies by domestic enterprises?

(f) Do RETs provide scope for technological leapfrogging energy consumption and production in developing countries?

(g) What measures can be put in place to support the development of local innovation capabilities? What is the role of international organizations such as UNCTAD?

(h) How can bilateral and multilateral assistance mechanisms, including those related to poverty reduction, be channelled more effectively towards the deployment of modern energy services and electrification?

(i) How can renewable technologies and tools be made more affordable?

(j) How can synergies between policies in different areas be maximized?

(k) What has been the role of cooperative energy provision?

(l) How can bilateral and multilateral assistance, mechanism, including those related to poverty reduction, be channelled more effectively towards the deployment of modern energy services and electrification?

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