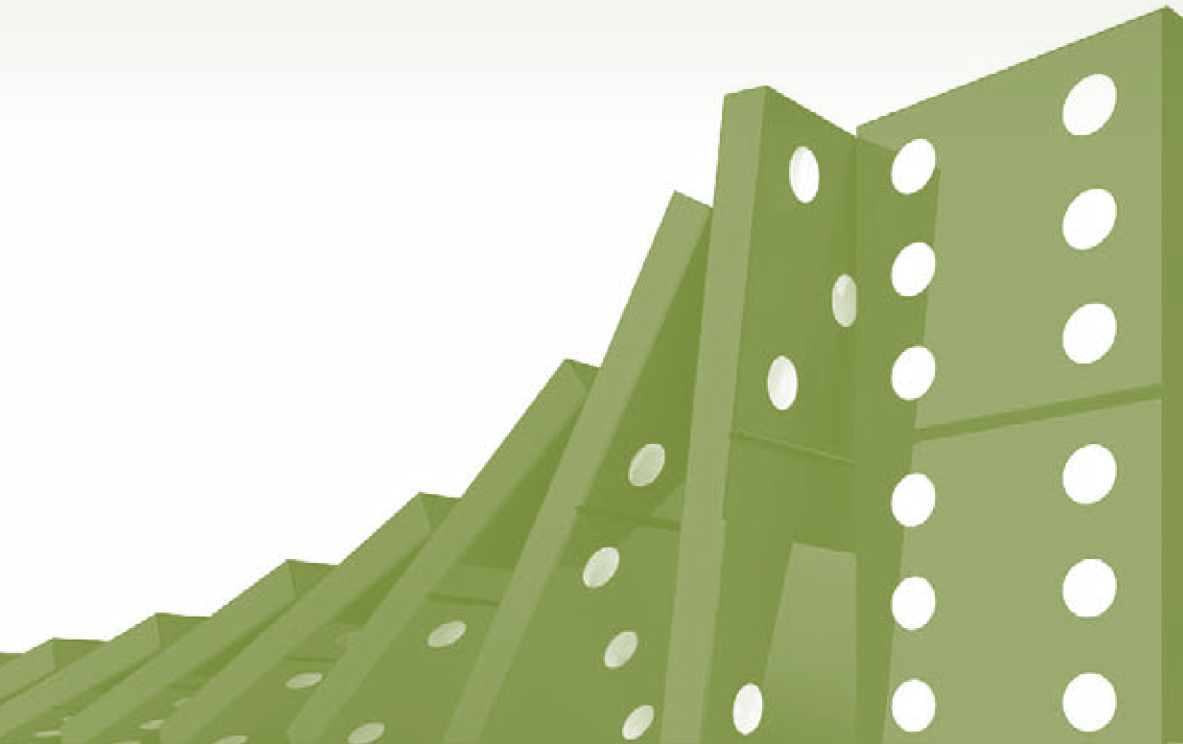
CHAPTER 4

GROWTH POLE: RENEWABLE ENERGY TECHNOLOGIES



I. Harnessing the Potential of Renewables: the Case of Energy Access in Rural Areas

Darlan F. Martí
UNCTAD secretariat

» The widespread deployment of renewable sources of energy is not only an environmental and developmental imperative; it can also be strategic in multiple ways. As a matter of fact, in addition to constituting a tool for climate mitigation, renewable energy technologies (RETs) can also be combined with rural electrification strategies to offer leverage for trade and investment growth, innovation, and employment creation.

» The utilisation of RETs in policies to provide poor rural communities with access to modern energy is not new, but has been given renewed momentum with the current economic, environmental, and food crises. Fully seizing this momentum depends on government's ability to identify policy synergies between agriculture, energy, climate mitigation and adaptation, rural development, innovation and investment policies, to name but the most important. This requires strong institutional capacity and regulatory frameworks as well as financial support, which are often lacking in many developing countries.

» Awareness about the environmental and developmental potential of RETs is a first step to their deployment. A second is policy coordination and coherence.

A. Introduction

Access to electricity and modern energy sources is a basic requirement to achieve and sustain higher living standards. It is essential for lighting, heating and cooking, as well as for education, modern health treatment and productive activities. Yet 1.6 billion people lack such access, and more than half of all people living in developing countries rely on the combustion of traditional biomass (e.g. wood) to meet their basic energy needs for cooking and heating. Lack of access to modern energy sources is both the result and the cause of poverty, as it exacerbates and perpetuates poverty. The poorer the population, the more likely it is to lack access to electricity and modern energy supply, and the more difficult it might be to reverse that situation.

While lack of access to modern energy supply in developing countries affects poor people in general, it is a particularly defining feature of rural populations. First, because rural populations are geographically dispersed, often far away from main urban areas, and hence cannot be easily or economically connected to existing national grids. Second, because rural populations tend to have limited disposable income to finance the initial costs of connection to grids, in-house wiring and the monthly payments of energy bills. The combined result is that resource-constrained developing-country governments might find the costs of extending national grids prohibitive, and investments may be unattractive or entail too high a risk for the private sector. Therefore, the challenge faced by governments is to utilize their limited resources in the most strategic manner so as to achieve maximum welfare benefits while at the same time making rural electrification projects attractive for private sector investors and sustainable over the long run.

Renewable sources of energy such as solar, wind, biofuels and small hydro can very conveniently be developed to generate electricity in small stand-alone systems, not connected to national electric grids. They can constitute economical options to deliver energy to remote rural areas. The current global concern about climate change, with its imperative to decouple economic growth from an increase in carbon dioxide emissions, makes investing in renewable energy sources particularly timely and strategic. Renewables provide an exemplary win-win result for economic growth and environmental sustainability. This article focuses on some of the opportunities created by these synergies. First, it summarizes the nexus between poverty and lack of access to energy, and then goes on to enumerate some of the main benefits of bringing clean, modern energy to rural areas. This is followed by a discussion of the most prominent renewable energy technology (RET) options that can be used in off-grid electrification projects, and considerations of how to scale up investments in such projects. Finally, it reviews typical tools that governments could employ to foster RET-based rural electrification projects and the possible sources of financing.

B. Energy Poverty and the "missing Millennium Development Goal"

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 2.5–3 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, and, at current rates of electrification, the number of people utilizing traditional biomass is expected to remain constant or could even increase to 2.7 billion by 2030 because of population growth (IEA, 2006).

Moreover, it is likely that the number of people who lack access to electricity could inflate 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 significant fluctuations in the prices 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).

Rural populations are hardest hit by the lack of access to electricity: 4 out of 5 people who lack access to electricity in the world live in rural areas. This is not surprising, as electricity consumption is closely correlated with wealth, and 75 per cent of the world's poor live in rural areas (World Bank, 2008a). Rural communities consume little electricity, and have little or no disposable income to pay for electricity services. Lack of access to electricity is also due to the difficulties in providing electricity to households scattered in large, isolated or remote geographical areas. Many governments have invested in the extension of national grids over the past three decades, in many cases reaching a large segment of urban populations. However, seizing these low-hanging fruit opportunities has exacerbated the urban-rural divide with respect to access to electricity. In all developing regions, electrification rates are significantly lower in rural areas. In sub-Saharan Africa, for instance, while 58.3 per cent of people living in cities have access to electricity, only 8 per cent of those living in rural areas have similar access (table 1).

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 countries	99.5	100	98.1
World total	75.6	90.4	61.7

Source: IEA 2006, table B1.
[a] The regional designations follow those used by the IEA.

Income and geographical isolation, however, are not insurmountable stumbling blocks, as shown by several success stories. One of the most commonly cited successful electrification programmes is that of China, which has reached a rate of more than 98 per cent in less than two decades (1985–2000). Despite some shortcomings, this achievement is impressive, both because of its scope and because Chinese electricity consumers pay their bills, unlike consumers in many other developing countries (IEA, 2002: 374). Another good example is Morocco, which has reached 97 per cent coverage over a comparable time span.

Lack of access to modern energy has consequences for all aspects of social, economic and environmental conditions prevailing in rural areas. Access to modern energy strongly influences and determines living standards (e.g. availability of lighting), access to water and sanitation, agricultural productivity (i.e. through irrigation), health (refrigeration for medicines and vaccines, and power for equipment), gender and education. Its centrality in promoting higher living standards and enhancing productive opportunities means that none of the Millennium Development Goals (MDGs) can be met without major improvements in the quality and quantity of energy services in developing countries.

A concern related to energy poverty is that poor people overwhelmingly rely on the burning of traditional biomass to meet their most basic energy needs. Traditional biomass solid fuels are wood, charcoal, agricultural residues and animal dung. In some sub-Saharan African countries (e.g. Chad and Sudan), biomass provides 90 per cent of all energy consumed, and it is estimated to account for most of the household energy needs even in oil-rich sub-Saharan African countries such as Angola (95 per cent), Cameroon (78 per cent), Chad (97 per cent) and Nigeria (65 per cent) (IEA, 2008). Yet there are a number of major problems associated with the utilization of traditional biomass, including the following:

- First, there are health hazards because of pollutants emitted during its combustion (e.g. carbon monoxide, small particles and benzene). The indoor concentration of such pollutants is often several times higher than concentrations recommended by the World Health Organization (WHO), and result in a higher prevalence of respiratory diseases,[1] obstetrical problems, eye infections and blindness, among others (IEA, 2002). There is consistent evidence that indoor air pollution increases the risk of chronic obstructive pulmonary disease and of acute respiratory infections in childhood – the leading cause of death among children under five years of age in developing countries. Evidence also exists of an association with low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, cataract, and, specifically in respect of the use of coal, with lung cancer. 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. WHO estimates that indoor air pollution ranks fourth in terms of the risk factors that contribute to disease and death in developing countries.
- 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, 2 to 7 hours are spent daily for the collection of biomass for fuel (IEA, 2002). Moreover, inefficient burning stoves unnecessarily increase cooking time.
- 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. But in some instances (e.g. in Africa), fuel wood collection does constitute one of the causes of tropical deforestation (Modi et al., 2006:30).
- 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 GDP in 2006 (Parikh et al., 2005).

While in absolute numbers it is mostly people in South Asia and to a lesser extent in countries in other subregions of Asia (China, Myanmar, the Philippines, Thailand and Viet Nam) that rely on traditional biomass, the highest proportion are those living in sub-Saharan Africa. Often, biomass is combined with other energy sources, such as candles, kerosene, diesel, gasoline or liquefied petroleum gas (LPG), to complement household energy needs.

C. Rural Electrification

Because of its centrality to the achievement of human development, access to energy has been defined as the "missing Millennium Development Goal".[2] 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). This is why the Johannesburg Plan of Implementation, adopted at the World Summit on Sustainable Development in 2002, addresses energy in the context of sustainable development. It calls upon countries to improve access to reliable, affordable, economically viable, and socially acceptable and environmentally friendly energy services.[3] Conscious of this, several countries have started implementing electrification programmes with a clear poverty reduction goal.

1. Unlocking development potential

The full poverty reduction potential of energy access depends on the availability of three types of energy: energy for cooking (e.g. electricity, natural gas or LPG), electricity for lighting and to power household and commercial appliances, and mechanical energy to operate agricultural and food processing equipment (e.g. for grinding), to carry out supplementary irrigation (e.g. from water pumping), to support other productive uses, and to transport goods and people. The benefits of electrification are direct and indirect. Direct benefits include improvements in living conditions, such as illumination (and hence also the opportunity to study longer hours in the evening or to work longer hours in family businesses) and improved cooking methods (and hence the reduction of health hazards associated with biomass burning). Moreover, access to electricity can also reduce energy costs, especially for lighting and small uses, resulting in savings for poor households.

In addition, electrification may have more ample indirect benefits. These include 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, Internet), and an increased ability of rural communities to retain doctors, teachers and other professionals as it improves living standards. Moreover, there are positive linkages between electrification and accelerated economic growth and employment generation, economic diversification and industrialization.

It is worth noting that there is an important difference between access to energy that improves living conditions (e.g. energy for lighting) and access to energy that enables productive activities (e.g. energy for water pumping and irrigation). While the first makes a direct contribution to better living standards and has several social dividends, only the second allows the fully-fledged economic and social transformations required to generate development spirals (figure 1).

In fact, where local community conditions are favourable, access to modern energy can stimulate the creation of new small and medium-sized enterprises (SMEs) and family businesses, or improve the competitiveness of existing firms (e.g. brick-making, silk production, textiles processing, sewing, joinery and handcrafts). It can also improve agricultural productivity (e.g. through irrigation), fisheries and fish farming, and enable the processing of agricultural and fish products (e.g. grinding, milling). Moreover, it may create new trading opportunities, for instance for perishable produce (by providing refrigeration). Evaluations of the impact of electrification show that the provision of lighting and power can unleash new productive activities or extend the length of the productive day. Many of these activities are undertaken by women, thereby increasing their chances for income generation and economic empowerment (Lallement, 2008).

In addition, investment in the provision of universal access to energy may generate numerous employment opportunities related to the manufacture, installation and maintenance of power generating units. There are several examples of projects based on RETs, for instance, 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 SMEs supply electricity to some 60,000 households (World Bank, 2008b).

The experience gained in rural energy access projects is likely to generate knowledge, expertise and manufacturing capacity in renewable-energy-related industries, which will certainly be a fast-growing economic sector in global trade for years to come. The production and innovation capacity that has been built in China's solar and wind RETs industry illustrates the employment, technological and investment opportunities that RETs may offer (see WU in this Review). An important lesson for the design of rural projects is that efforts should be made to maximize local content and local knowledge in order to achieve the most positive results. For instance, biogas digesters utilize simple technology and can therefore be manufactured lo-

Figure 1. Renewable energy for people and the environment

Source: *UNDP Annual Report 2009: 27*, at: www.undp.org/publications/annualreport2009/report.shtml.

cally. 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. There is also a very interesting application of rural electrification (mainly mechanical power for productive industries using very simple technologies), which relates to the installation of multifunctional platforms in West Africa.[4] The developmental and environmental potential of these platforms is even more strategic if they are based on locally produced biofuels or on hydropower.

There are so many welfare benefits of utilising RETs to provide access to modern energy in rural areas that governments should approach this objective as a full component of an integrated development policy package, and not as a stand-alone element of investments in infrastructure. Seen in that light, investments in providing access to rural energy should be part of governments' public spending priorities, made all the more attractive since it can unleash the developmental potential of communities. By creating an enabling environment for the emergence of income-generating or income-improving activities, electrification projects can directly contribute to poverty eradication policies.

The gains in productivity in the agricultural and food sector, for instance, can be particularly rewarding from the social viewpoint. Benefits for agricultural production include irrigation (perhaps with the use of water pumps), increased utilization of motors, food processing, refrigeration and also better access to training through information and communication technologies (ICT). Successful electrification programmes linked to agriculture would not only result in more competitive farming and create employment opportunities, but would also improve trading opportunities and local food security, including through the reduction of post-harvest losses. The electrification of agriculture can yield several value addition opportunities, improving incomes and diversifying their sources, thereby improving the resilience of rural communities. Opportunities offered by policy synergies of this type highlight the importance of participatory approaches in the design of RET-based electrification policies, and call for policy coordination and coherence.

This highlights an essential aspect of rural electrification strategies, namely, that to deploy its full poverty developmental potential, electrification has to be well embedded in local or national poverty reduction strategies and considered within a broader development context. The mere installation of off-grid energy generating units is likely to fall short of triggering social and economic transformations commensurate with the full potential of RET-based electrification.

This translates into a developmental approach to energy problems. For instance, energy security is usually understood as a geo-strategic imperative, requiring the diversification of national energy mixes (to rely on more than one type of energy) and sources of supply (to rely on more than one country or region). That is certainly a worthwhile country-level guideline. However, what matters from a developmental viewpoint is that all individuals should have access to the bare minimum level of modern energy services. India's Expert Committee on Integrated Energy Policy defined energy security as the ability of the government to "supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected" (Government of India, 2006).

The investment policy challenge for governments is therefore to utilize limited resources in the most strategic manner, so as to maximize the social benefits of projects while ensuring the social and geographical equity of investments. The ultimate goal is for initial installation investments to create new income streams and trigger transformations that release the economic growth potential of rural communities.

2. Renewables: strategic in multiple ways

In addition to the general welfare improvements of rural electrification, additional benefits can accrue if electrification is based on RETs. In fact, not all electrification projects need (or indeed can) be based on an extension of national electricity grids. Mini-grids or off-grid electrification projects can be very well adapted to rural conditions. Typical RETs include solar energy (e.g. solar home systems (SHS)), wind, biomass and hydro power (see section D below for a description of the technologies). Renewable energy-based rural electrification is strategic in numerous ways.

First, RETs are very suitable for decentralized, stand-alone, small power-generating units. Their suitability depends on the availability of natural resources, the degree of maturity of a given technology and, ultimately, an assessment of cost-effectiveness. While grid extension may prove more cost-effective in some locations, off-grid RETs hold considerable promise for the electrification of communities that are not expected to be connected to national grids in the near future. Decentralized sustainable energy projects based on solar photovoltaic (PV) systems, wind-electric or micro-hydroelectric simple technologies are sufficient to provide lighting and electricity for basic appliances, and power for small-scale productive activities such as electric fencing, water pumping, irrigation and ice-making (see section D and table 2 below). This means that decentralized renewable energy units can provide a cost-effective solution to quickly improve social and employment opportunities in isolated poor rural areas (World Bank, 2008b).

A second, and related point is that off-grid renewable energy units do not entail an increase in overall national supply capacity managed through central grids. Since the units are not connected to the main national grid, there is no new demand on what is typically an already stretched national installed supply capacity. This can significantly shorten the time frame for implementation of rural electrification projects.

Third, 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[5] 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.

Fifth, while there are several business and regulatory models for the installation of off-grid renewable-based energy units and for the supply of power, 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, Covarrubias and Martinot, 2000). 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.

Finally, as already mentioned, renewable energy sources also offer several manufacturing opportunities. 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 and international demand for RETs. Trade in RETs has in fact been brought into focus, for instance, as a possible contribution of the WTO to global climate mitigation efforts (see Vikhlyaev, Fliess, Zhang and Jha in this Review).

3. Opportunities for climate change mitigation and adaptation

Decentralized renewable energy production units have obvious benefits for the sustainability of developing countries' economic growth. Electrification projects should be designed in an integrated manner to also include capacity-building for improved land management, more sustainable agricultural practices and recycling. These are necessary to ensure the fullest sustainability of projects. For instance, certain renewable energy units utilize lead batteries, the disposal of which must be coordinated with local recycling policies.

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. This confirms and reinforces the case for policy coordination and policy coherence.

With respect to economic growth, renewable energy-based rural electrification projects offer significant benefits. First, they make a contribution towards decoupling economic growth from CO_2 emissions. Second, investments in renewable energies send a political signal about developing countries' commitment to climate change mitigation and a global climate change regime. Third, because the power supplied is likely to be utilized for agricultural production, access to renewable energy can, if coupled with capacity-building and training, trigger the progressive greening of agriculture and agro-processing, thereby creating new development and trade opportunities. However, the extent to which a real greening is possible would require an assessment of the entire energy balance of agricultural systems (for instance, to reduce the reliance of farms on fossil fuels for tillage, harvesting, transportation and fertilizers).

D. Scaling up renewables: feasibility and prospects

Because of the multiple benefits of RETs-based electrification, scaling up projects is a developmental and environmental imperative. Many such projects and programmes are being implemented in a good number of countries, generally in collaboration with international development partners. However, the number and scope of such programmes will have to increase if the number of rural poor is to be significantly reduced to levels that allow the attainment of the MDGs by 2015. In this regard, major development partners[6] have recommended that energy services be explicitly addressed in planning for poverty reduction (Modi et al., 2006: 39) in particular that:

1. Half of the people who currently rely primarily on traditional biomass for cooking should switch to alternative fuels, such as LPG or electricity. In addition, support should be given to (a) the utilization of improved cooking stoves, (b) reducing the adverse health impacts from cooking with biomass, and (c) increasing sustainable biomass production.
2. Access to electricity should be provided to all in urban and peri-urban areas.
3. Modern energy services (in the form of mechanical power and electricity) should be made available at the community level for all rural communities.

These recommendations were considered not only necessary, but also achievable. In addition, part or perhaps even the bulk of that effort should be based on RETs. Several RETs have attained commercial maturity for the implementation of rural electrification projects, and there is also a wealth of past experience as well as new experimentation of business models that could ensure the long-term sustainability of such projects.

1. Technologies

An important lesson learnt from the design and implementation of rural electrification projects over the past three decades is that policymakers should not impose technology options, and that projects must be technology neutral (World Bank, 2008b). That would allow service providers to conduct cost-benefit comparisons of all options available and to choose the one that is the most economical, suitable to local resources and adapted to the expected demand. The analysis must also consider whether grid extension is a more appropriate electrification method for a given location. The analysis of all parameters should be conducted free from constraints regarding a predetermined technology choice (technology neutrality), and should strive to utilize as much local content as possible with the aim of maximizing trade, economic and investment benefits.

If a decision is made that grid extension is not an adequate option for a specific electrification project, it can be difficult to assess which off-grid technology is best suited to each circumstance (table 2). There are numerous off-grid RET and fossil-fuel-based options available (box 1), as well as combinations of technologies for use in hybrid units. While the availability of renewable energy resources varies depending on the site, many resources are abundantly available in developing countries, and some are well suited for off-grid, small rural electrification projects. This does not

Table 2. Decision-making steps in off-grid electrification technology options

⇨ *Grid extension vs. off-grid electrification*: choice depends on such factors as the distance of communities from the grid, the geographical dispersion of settlements, the type of load and the size of demand.

⇨ *If an off-grid solution is retained*: a preliminary study should be made of availability of local resources, income level of users (ability and willingness to pay), equipment availability, possible synergies with other public investment programmes and identification of opportunities to utilize electricity for productive activities.

Concentrated (some productive load) **Mini-grid**	Dispersed (mainly household lighting) **Individual systems**
• Diesel • Renewables: wind, solar PV, hydro, biomass gasifier, biomass direct combustion • Diesel – renewables hybrid	• Solar home system, wind home system, pico hydro (i.e. hydropower generation of under 5kW), battery

Source: Adapted from World Bank, 2008b, figure 1.

Box 1. Categories of sources of renewable energies

1. Combustible renewables and waste (CRW) such as:
   a. Solid biomass: organic, non-fossil material such as wood, wood waste, woody materials generated by industrial processes (e.g. paper industry) or provided by forestry and agriculture (e.g. firewood and wood chips), and wastes (e.g. straw, rice husks and nut shells);
   b. Charcoal;
   c. Biogas (mainly methane and carbon dioxide produced by anaerobic digestion of biomass);
   d. Liquid biofuels;
   e. Municipal waste: combustion of biodegradable material from residential, commercial and public service sector waste;
2. Hydropower: kinetic energy of water converted into electricity;
3. Geothermal: heat emitted from the earth's crust (steam or hot water), used directly or transformed into electricity;
4. Solar: solar radiation exploited for hot water production and electricity generation;
5. Wind: kinetic energy of wind exploited for electricity generation; and,
6. Tide, wave or ocean: mechanical energy derived from tidal movement, or the wave motion of ocean currents, exploited for energy generation.

Source: The IEA (2007, annex I).

mean that all the necessary technologies to exploit these resources are also concomitantly cost-effective or socially acceptable in developing countries.

Among the elements that must be considered in choosing a technology, site specificities figure prominently. Major factors include availability of renewable resources, the load needed and the type of utilization, the cost effectiveness of various options and investment parameters (table 3). For instance, the abundant availability of a natural resource may make certain RET options attractive in one location but not in another. In Kenya, for example, there is some cost-effective geothermal production that can feed into small grids (and even into the national grid), but this is not the case in neighbouring Uganda and the United Republic of Tanzania. Because of the impact of project design on the long-term viability of a project, the collection of baseline data on energy consumption, income and willingness to pay, and a sound understanding of local conditions and expectations is a prerequisite. For instance, it is necessary to monitor wind speeds for at least one year before building a wind turbine (World Bank, 2008b: 8).

The most promising technologies that could offer large-scale deployment opportunities in rural areas include biomass, solar, wind and hydropower. For specific remote applications, a selected number of renewables have proven not only to be cost-competitive but also to be able to overcome the barriers associated with ensuring adequate maintenance support. The most attractive options have often been applications that are income generating and are linked to existing agricultural activities or agro/forest industries. The following are notable examples (Karekezi, Kimani and Wambile, 2007):

- Wind pumps for irrigation, in South Africa (with over 100,000 wind pumps in operation) and Namibia (with close to 30,000 wind pumps);
- Small hydropower units for powering remote rural agro-processing factories in tea, coffee and forest industries in Kenya;
- Geothermal heat applications in remote areas used for rural horticultural production (flowers, vegetables and fruits) in Kenya;
- Co-generation in agro/forest industries in Côte d'Ivoire, Kenya, South Africa, Swaziland, Uganda and the United Republic of Tanzania;
- 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.

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

Table 3. Examples of small-scale, off-grid energy systems

Technology	Applications	Pros	Cons
Diesel engines	- Water pumps - Mills - Refrigeration - Lighting and communication	- Easy maintenance - Continuous energy (24h/day) - Enables income-generating activities	- High fuel costs - Noxious and CO_2 emissions
Small biomass plants	- Water pumps - Mills - Refrigeration - Lighting and communication	- Enables income-generating activities - Base load operation, continuous operation possible	- Noxious emissions
Mini/micro-hydroelectric plants	- Mills - Lighting, communication and other - Ice-making (2-10kW) - Micro-irrigation (1-3kW) - Refrigeration (0.5-10kW)	- Long life, high reliability - Enables income-generating activities	- Site-specific - Intermittent water availability
Wind	- Water pumps - Mills - Lighting and communication - Ice-making (2-10kW) - Micro-irrigation (1-3kW)	- No fuel cost - Enables income-generating activities	- Expensive batteries - Intermittent energy service
PV/solar	- Basic lighting and electronic equipment (cell-phone charging) - Water-pumps for fish farms; - Micro irrigation (1-3kW)	- No fuel cost - Enables income-generating activities	- High capital costs - High cost of battery replacement - Needs further R&D

Source: Adapted from IEA, 2002, table 13.4 and World Bank, 2008b, table 2.

wind home systems (WHS). 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, 2008b: 6).

In addition to their environmental drawbacks (e.g. GHG emissions from combustion), engines powered by fossil fuels (diesel, gasoline or kerosene) have two additional drawbacks. First, they require regular, skilled maintenance. Second, isolated communities rely on the delivery of fuel, the price of which can be very high and subject to strong volatility. Yet these engines have been quite commonly deployed, particularly in 5–10kW portable systems or in hybrid combinations with RETs. This was common practice mainly before RETs reached commercial or near-commercial maturity. RETs, on the contrary, generate no or few fuel costs, but some RET equipment also requires regular skilled maintenance services (e.g. biomass gasifiers). Moreover, renewables are also subject to location specificities such as the seasonality of natural resources (e.g. water resources for hydropower generation or agricultural residues for biomass digesters). The intermittent availability of natural resources (e.g. wind, water, biomass fuel) increases the risks to off-grid renewable units and helps explain why RETs are sometimes combined with diesel generators, especially when interruptions in supply are not desirable. However, such back-up power increases the overall costs of the systems. Other types of hybrids are also possible, such as photovoltaic-wind hybrid systems, which take advantage of the varying availability of the solar resource and the wind resource, allowing each renewable resource to supplement the other, and increasing the overall capacity factor.

A new development is the deployment of technologies which have attained greater commercial maturity recently. This includes, for instance, the introduction of off-grid solar PV products that are much smaller than the traditional 20–50 watt solar PV systems (sometimes called "pico-PV"). The advantage of these systems is that 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).

To sum up, each technology has its own advantages and disadvantages, and therefore varying degrees of suitability to a given site's specificities, utilization and expectations. A comprehensive understanding of such factors requires site monitoring and assessment. Moreover, each technology option entails costs and a degree of acceptance which also vary from one country to another. The extent to which RETs can effectively accelerate rural electrification (and perhaps more generally improve access to modern energy) depends largely on the cost effectiveness of RETs relative to other energy options.

2. Costs

Many RETs are now commercially viable and economically more attractive than grid extension or off-grid, diesel-powered systems. PV technologies, for instance, have achieved impressive cost reductions over the past few years: every doubling of the volume produced achieved a cost decrease of about 20 per cent (IEA 2007, annex II). However, installation and operating costs vary considerably by location, configuration and context. As a result, it is difficult to draw general conclusions.

The costs of electrification are location-specific and hence very uneven across countries: the poorer and more rural the population, the more costly it is to provide electrification: for example, in 2001, the cost of connection to conventional grids was $240 in South Africa, and over $1,000 in Uganda (IEA, 2002). The cost of connecting a rural home to the national grid in Kenya is equivalent to seven times the per capita gross national income (GNI) (REN21, 2007: 35).[7] The unit costs of RET-based electrification tend to be higher than those of grid extension, particularly because of the capital costs involved. In some countries, many low-hanging fruits have already been exploited (particularly in Asia), so that investments must now focus on last-mile users that are much more difficult to reach. In other instances, there are still many easily achievable opportunities. In Africa, for example, the penetration of cheap, decentralized RETs from Asia could significantly increase with the removal of trade barriers.

The economic assessment of RET deployment has different aspects that can be more or less significant depending on who conducts it. Service providers will be interested in calculating capital costs, such as equipment and installation costs, to match those with electricity tariffs and assess rates of return. Consumers would be sensitive to the cost of the electricity generated, and hence its affordability for households and productive activities in local communities. Moreover, consumers will also factor in the costs of operation (e.g. fuels), maintenance of equipment and possible replacement of parts (e.g. batteries). Governments may be interested in knowing the amount and duration of subsidies that may be needed to ensure the viability of programmes, as well as the needs for capacity-building, technical assistance and training. Governments may also consider cost opportunities for bundling rural services together, or assessing the energy component of other public infrastructure decisions.

Furthermore, a cost-benefit analysis of investments in rural renewables-based energy supply must take into account the social and environmental benefits that these sources of energy provide. While the environmental benefits, including in the context of climate change mitigation, are obvious, social aspects are also important. Several social benefits justify investment in renewable energies. These include the fact that renewables can bring energy to the poor much faster than the expansion of centralized systems. Moreover, as mentioned earlier, renewables have direct benefits for income generation if properly linked to support for productive activities. Economic analysis of World Bank projects reveals very high returns on energy investments, with consumer surplus ranging from 27 per cent to 94 per cent for projects in Bolivia, China, Indonesia, the Philippines and Sri Lanka (World Bank, 2008b). A survey of electrified and non-electrified villages in Bhutan found that switching from kerosene to electricity resulted in a surplus of 33 per cent for consumers. The study also found that electrified households also disposed of 24 per cent more income than households that lacked access to electricity (Bhandari, 2006).

Against this background, potential welfare gains from public investment in rural energy infrastructure and RET deployment could exceed the costs associated with lack of access to energy or the utilization of unsustainable sources of energy. It is also crucial to consider the profitability of investments by private sector service suppliers who incur initial risks and market development costs. In several developing countries, examples abound of commercial deployment and interesting rates of return from RETs in rural electrification projects. For instance in India, projects involving biomass gasification for mechanical power utilized in silk and textile processing have shown payback periods as short as one year. The drying of cardamom, rubber and bricks has also shown short payback times and improvements in productivity gains from a shortening of drying time (REN21, 2007: 34).

There are no overall quantifications of the investments needed to provide universal energy access in rural areas. Indeed, it is difficult to determine the exact number of people living in rural areas for whom off-grid renewable energy projects could be implemented. This means that there is generally no precise quantification of the size of markets and private sector opportunities (World Bank, 2008b: 3).

The IEA has calculated that completely halting the utilization of traditional biomass by 2015 would necessitate the adoption of alternative fuels and technologies, such as LPG stoves and cylinders, by 1.3 billion people at a maximum cost of $1.5 billion per year (IEA, 2006). The economic benefits of meeting that goal are deemed to far outweigh those costs. As a matter of fact, WHO estimates that meeting that goal would yield annual average benefits of $91 billion worldwide (cited in IEA, 2006: 440, table 15.6). However, these costs concern exclusively biomass and cooking fuels, and not the costs of providing other types of energy (e.g. electricity). In fact, other than project-specific information, there seems to be little information available on the costs of RETs as a source of household energy relative to fossil fuels.

The remoteness, low density and low income level of rural populations raise the costs of electrification to sometimes prohibitive levels, and reduce profitability for private investors and operators. Moreover, the training, technical assistance and capacity-building that are needed to support rural electrification schemes add to capital costs. Given large capital costs and high associated risks, service providers would need to charge high connection fees and monthly rates to recover their investments, which would undermine the affordability of electrification for poor consumers. To unlock this energy-poverty trap, governments must play an active role in partly covering the capital costs and sometimes in subsidizing monthly payments for the poorest consumers. The challenge for governments of poor countries is therefore to utilize limited resources in the most strategic manner, enhancing the attractiveness of investments for private service suppliers while ensuring maximum social, environmental and economic benefits.

E. Tapping regulatory and financial opportunities

Several governments have undertaken important reforms of their energy sectors. For example, many have embarked upon programmes of privatization of public operators, while others have reformed their regulatory environments (e.g. decoupling energy production from its distribution). The objective of these reforms has generally been to attract private capital for modernizing old or poor utilities. While these reforms have sometimes improved and enhanced electricity supply in urban areas, in most instances they have had little impact on improving the attractiveness of rural electrification projects for private service suppliers.

Financing remains a major barrier in RET deployment. There are, nevertheless, several experiences of regulatory reforms and policy incentives that have successfully provided the necessary impetus to rural electrification programmes. Moreover, innovative financing options (e.g. microfinance) and business models (e.g. concessions, public-private partnerships) offer promising avenues. Removing barriers, exploring policy synergies and creating conducive regulatory environments require the building of institutional capacity and identifying leadership sources at the national and local levels. National measures to support the demand for RET and generate RET markets can be extremely effective in inducing the production of RETs and their deployment (see Wu, Zhang and Jha in this Review).

1. Incentives and national policies

By early 2009, policies to promote renewable power generation (not only in rural areas) with feed-in tariffs existed in at least 64 countries, both developed and developing, including 45 countries and 18 states/provinces/territories. In 2008-2009, new laws and policy provisions for renewables were introduced in several developing countries, including Brazil, Chile, Egypt, Mexico, the Philippines, South Africa, the Syrian Arab Republic and Uganda (REN21, 2009). Many countries have tested the enormous potential of universal energy access for poverty reduction strategies, such as Brazil's "Luz para todos" and China's "township electrification" programmes. A number of African countries have created specific institutions (i.e. rural energy agencies and rural electrification funds) and special regulatory and legal structures to facilitate increased access to energy. Other countries (e.g. Argentina, Bangladesh, Bolivia, Brazil, Chile, China, Guatemala, Honduras, India, Indonesia, Nepal, Nicaragua, the Philippines, Sri Lanka, Thailand and Viet Nam) have updated national rural electrification strategies to mainstream renewables as one of the basic technology options (REN 21, 2007).

Various factors influence the long-term sustainability of projects, and hence determine their success. Among these factors, the affordability of the electricity generated is 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. This can limit the environmental or social benefits of public investments, or undermine the profitability of service providers. For instance, while the electricity infrastructure has reached almost 90 per cent of the Indian population, only 43 per cent are actually connected to it because they cannot afford the costs. By contrast, the electrification process in China has been more successful to the extent that it has achieved effective access to modern electricity. Moreover, Chinese consumers pay their electricity bills to a larger extent than the poor in other countries where connections have been established (IEA, 2002: 376).

Shifting from traditional, low-quality biomass to modern energy sources depends on the availability of other energy sources, on the affordability of alternatives and on cultural preferences (IEA, 2002: 369). These factors help explain why poor households utilize several complementary sources of energy to meet their needs, rather than switching straight away to electricity when provided access to it. In other words, consumers will naturally choose energy mixes that reflect the marginal cost of different energy sources (e.g. electricity used only for lighting, television or radio, charcoal or LPG for cooking, kerosene for heating). Even when provided with affordable energy alternatives, households may not completely stop utilizing biomass (for instance, even high-income households in India maintain a traditional fuel wood stove to cook traditional dishes). The utilization of more than one source of energy (e.g. wood, LPG, electricity) may in fact enhance people's perception of energy security (IEA, 2006).

To ensure fuel switching, project design must incorporate capacity-building, to the fullest extent possible, to overcome cultural inertia or resistance. It must also include financial support to improve the affordability of initial and operational costs. This further highlights the importance of designing holistic projects, seen as developmental packages and not as mere infrastructural projects.

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).

2. Affordability

There are two main barriers underlying poor access to electricity:

1. The initial connection to the grid or mini-grid and in-house wiring, equipment purchase and installation costs, which are too high for poor households; and,
2. The monthly charges, which can dissuade low-income consumers from utilizing electricity (or utilizing it fully), particularly if wages are irregular or insufficient.

Governments can act on both fronts. Subsidies are a classic, often 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). Subsidies provided for the manufacture, acquisition and instalment of renewables were largely responsible for the dissemination of technologies in poor countries: among others, biogas digesters in China and India, improved biomass cooking stoves in Kenya and some other African countries, and SHS in Sri Lanka and Thailand. In the case of renewables, the bulk of deployment costs relate to the purchase and installation of equipment (capital costs).

In addition, governments may subsidize electricity costs over a given period of time to ensure that the poorest households have access to a basic level of services. Governments may, for instance, provide income transfers to the poorest households to reduce the relative burden of spending for energy services and other basic services. While safety nets of this type allow targeting the neediest beneficiaries, and hence utilizing resources more strategically, they also require rather sophisticated institutional capacity to identify needs and deliver the appropriate social benefits. Alternatively, subsidies can be incorporated in tariff structures: for instance, the first 50–100kWh 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". Commercial and industrial users could be charged higher rates, while SMEs would need more favourable treatment. Other ways to mobilize resources through tariffs include setting a transparent surcharge applied to higher income, commercial or industrial consumers, and using the proceeds to extend the service to poorer consumers. Such a system has been successfully implemented in Brazil (Lallement, 2008).

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. In India, for example, although the Government finances about 60 per cent of the estimated subsidy needs, the benefits do not reach the intended beneficiaries due to poor targeting. Therefore, to improve access to electricity by the poor, the Expert Committee on India's Integrated Energy Policy recommended that existing subsidy programmes be better targeted. A system of lifeline tradable entitlements delivered through smart debit cards could potentially be the answer (Government of India, 2006).

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. There are many examples of subsidies that never reached the poor and discouraged efficient consumption. Besides, subsidies generate rent-seeking behaviour and, once introduced, it is very difficult to phase them out. 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.

Subsidies should benefit consumers and businesses that would not otherwise have access to energy supply. However, they must provide an encouragement, not an end, for both users and suppliers. Subsidies must foster market development, not destroy business opportunities. In sum, subsidies must effectively reach the intended beneficiaries, encourage the provision of least-cost services (e.g. avoid covering operating costs), and, overall, be cost-effective, that is, achieve maximum social benefits for each unit spent (Barnes and Halpern, 2000).

In addition to subsidies, other measures can improve the affordability of energy. For instance, in some rural areas, the greatest challenge for farmers can be that the payment cycle for electricity (connections and monthly bills) does not match the income cycle (once or twice a year, after the harvest). Simply adapting the modalities of payment to the profile of agricultural users could make the difference.

Another important and complementary tool 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 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 (NGOs).

3. Profitability

Government financial support in renewable-energy-based rural electrification programmes should necessarily be temporary and time-bound. 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. This highlights the importance of the private sector in driving or sustaining electrification projects, and therefore includes the need to ensure profitability of investments for all operators such as commercial banks, RET retailers and service providers.

In "pockets of opportunities" (Reiche, Covarrubias and Martinot, 2000), 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, 2008b: 11). However, in most cases, incorporating start-up costs in the costs of energy supply would exceed the ability of the rural poor to pay. Yet studies show that the poor are often willing to pay for higher quality energy services but may be deterred from obtaining those services due to high access costs (Barnes and Halpern, 2000).

By supporting start-up costs, and sometimes electricity rates, governments can greatly improve the commercial viability of investments. Subsidies can unleash demand and open business opportunities. 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 renewable equipment from import tariffs and other taxes (experimented in Kenya and the United Republic of Tanzania (World Bank, 2008b)). The extent to which this is effective depends on the size of demand for these products and the rates at which such tariffs and taxes are set. However, because components and renewable equipment often have several uses, governments may be reluctant to generalize the application of such systems. (See the commentary by Vikhlyaev in this Review concerning the role of import tariffs and non-tariff barriers in the wider deployment of renewables, as well as the commentary by Zhang, who describes some additional measures needed in a package for the global dissemination of RETs.)

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. It entails overcoming technology resistance, awareness-raising, training of local technicians, technology demonstration, and upstream involvement of the population to increase local ownership. The key element resides in the identification of business opportunities at all levels, the creation of cooperatives and the insertion of electrification investments within broader policy objectives (e.g. irrigation, product processing and diversification, and employment generation). Furthermore, the deployment of RET in public buildings and facilities (e.g. schools, dispensaries and water pumping and purification) can significantly increase demand, may justify village mini-grids, and improves investment security because of the assurance of regular monthly payments. In addition to improving profitability and reducing risks, this obviously increases the social benefits of investment, and may in turn maximize the possibility of income generation.

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 source and greater cooperation among system operators with the aim of improving the security of energy supply, demand and transit. Emerging service delivery models include (Reiche, Covarrubias and Martinot, 2000):

- "Decentralized virtual utilities": the enterprises selling electricity charge a fee for their services, either through fixed monthly payments or through prepaid cards (experimented in South Africa);
- Local electricity retailers: local small businesses or cooperatives establish and run a business after accessing credit finance (for example, the establishment of independent rural power producers in India);
- Energy equipment dealers: RETs are distributed by local retailers who are able to penetrate low-income and remote areas, and secure credit for off-grid customers;
- Creative concessions: successful bidding companies are offered time-bound concessions to provide electricity in designated areas as a monopoly (e.g. Argentina, Senegal) or under competition (e.g. Cape Verde).

4. Political vision and commitment

The single most important objective of a RET-based electrification project is, of course, to ensure that the infrastructure installed produces positive changes beyond the time frame of project implementation.

The multiple benefits of RETs and their numerous possible synergies with other public policy priorities highlight the centrality of policy coherence and institutional coordination. Fully harnessing the human development and environmental potential of electrification requires weighing multiple policy objectives, preventing or removing conflicting incentives, and exploiting synergies with other public investment decisions. Two illustrations of lack of policy coherence are subsidies for fossil fuels and the absence of microfinance to support projects.

Policy coherence in itself is a challenge, particularly in developing countries. First, because rapid economic growth brings rapidly evolving social and economic priorities, which at times can be difficult to oversee and reconcile. Second, because coherence and coordination require institutional capacity and strong regulatory frameworks, which typically are lacking in poor countries. Third, because prioritization and coherence require political leadership, commitment and vision, which might be difficult to mobilize, given the numerous competing social and political needs in poor developing countries. The inclusion of RET deployment and rural electrification goals in Poverty Reduction Strategy Papers or National Development Plans can provide a good platform to achieve greater coherence. In this respect, political leadership and commitment are likely to be more forthcoming if electrification is indeed part of a development and income-generating package.

A useful instrument for promoting coordination is to adopt a multisectoral approach to an electrification policy; that is, to coordinate action among public agencies and ministries in order to identify possibilities for joint investments, synergies and service bundling. An interesting attempt is the Senegalese CIMES/RP,[8] 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.[9]

In addition to high-level commitment, one of the clearest lessons from the implementation of electrification projects over the past few decades is that local stakeholders must be closely involved in the design and implementation of projects to ensure an adequate ownership of the investments. In addition, 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. For instance, after several years of an electrification programme with full subsidization of household PV systems, it was observed that many households had sold their systems (Barnes and Halpern, 2000). These systems might have made economic and financial sense, but the households concerned felt they were not useful, which clearly hindered the achievement of the intended project results. Similarly, a survey of past electrification programmes demonstrated that projects fell short of delivering their full developmental and poverty reduction potential. User dissatisfaction, difficulties in servicing equipment and lack of awareness may mean systems fall into disuse or run below planned capacity, which in turn further undermines the commercial viability of the investments. A survey of 6,000 households in the Lao People's Democratic Republic revealed that almost 85 of the SHS systems were not working properly, and that failure to replace batteries meant households benefited from only 30 minutes to one hour of electricity every day (IEG, 2008, box 5.4). It was also estimated that once electrified, 80 per cent of the electricity consumed was used for lighting and watching television, both worthwhile benefits (access to television improves knowledge and reduces fertility), but disappointing compared with the potential of electrification for income generation, productivity gains, education and health improvements (IEG, 2008). Consumer education and a focus on productive opportunities to stimulate demand and ensure that consumers derive maximum benefits at the lowest cost are therefore an essential element in any electrification programme.

The imperative to reduce poverty and achieve the MDGs certainly provides a compelling enough policy argument in favour of energy investments. However, the political attractiveness and full development potential of these investments require the utilization of energy for income-generating activities. This requires identifying and building upon "pockets of opportunity". Such pockets may consist of rural areas where successful agricultural activities are already being conducted with some degree of competitiveness and where electrification would most certainly help realize those areas' social, production and trading potentials. There is huge scope for exploiting synergies between

Table 4. Funding options for environmental programmes

Main beneficiaries	Funding mechanisms	Role and activities of government	Rationale for government role	Examples
Direct income generated by investments or productive activities	Income is directed to those working for wages or profit	Government market regulators provide regulations, subsidies, promote price stability, foster formal employment through SMEs and cooperatives	Markets do not function effectively and the poor and the environment carry the burden of continued market failure	Consumer surplus from cheaper energy bills, income from equipment manufacture, increased productivity of family businesses
No direct income but benefits accrue to the poor	Government funding from poverty relief funds	Government as buyer (on behalf of poor beneficiaries). Buys services through the funding of public employment programmes	Poor are not able to afford to pay for the benefits	Water pumping for drinking, lighting, reduced indoor pollution, better nutrition from refrigeration, access to knowledge
Benefits that accrue to third parties	Government funding, with funds raised through special levies or taxes	Government acts as intermediary: buys services through funding or develops methods for quantification of benefits to establish a fair price, sells services through taxes, levies or user charges	No existing market mechanism for beneficiaries of the services to compensate those delivering the service	Energy delivery by rural companies, water pumping for irrigation, refrigeration of medicines
Benefits that accrue to government	Government funding, derived from general taxes or cost savings	Government acts as buyer. Buys services through the funding of public employment programmes, and offsets programme costs against other savings if applicable	Government is the main beneficiary of the service	Improved ability to retain trained education and health personnel in rural areas, income streams, increased productivity
Benefits that accrue to society as a whole	Government funding or sale of services on (international) markets	Government acts as buyer for downstream beneficiaries. Buys services through the funding of public employment programmes. Sells them on international markets if applicable	Benefits are general, long term and generally not priced, and government acts in its role of investing in the long-term public interest	GHG reduction from fuel switching and carbon sequestration (mitigation), increased income resilience (adaptation), land management

Source: Adapted from UNDP, 2009.

various policies in this context (e.g. promotion of SMEs, trading or export support and capacity-building for sustainable or organic farming).

5. Finance

The argument that RET deployment for rural electrification carries multiple benefits for synergies with climate adaptation and mitigation, as well as investment opportunities, should not minimize the challenges associated with delivering universal access to energy. Even with conducive regulatory and policy environments and innovative business models, the costs of universal access to modern energy remain high. The finance needed to provide access for the remaining 1.6 billion (rural and urban) people who lack energy supply is estimated to amount to $25 billion in total by 2030. However, firms' reduced cash flows, the credit crunch and more constrained government budgets due to the current financial and economic crisis could make it more difficult to mobilize such a level of finance over the short to medium term.

One aspect of investments that could be explored strategically is to mobilize multiple sources, 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 (table 4), 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 is already happening, although there are still tremendous opportunities to be tapped. An interesting illustration of an approach that utilizes multiple sources of finance is the EmPower Partnership Programme being implemented in India (described in Sharan in this Review).

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, 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, UNEP's African Rural Energy Enterprise Development Initiative (AREED), supported by the United Nations Foundation, works with African NGOs 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).

6. Bilateral and multilateral financing mechanisms

There are 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. This offers many opportunities for the achievement of rural electrification objectives. The following is a selection of some of those funding schemes:[10]

- *The Global Environmental Facility's* (GEF) *Trust Fund,* under its Climate Change focal area,[11] finances several projects to promote the adoption of renewable energy by assisting governments to remove barriers and reduce implementation costs to make renewables more attractive. It has projects, including several focusing on rural areas, in a number of developing countries: Argentina, Bangladesh, Bolivia, Botswana, Burkina Faso, Cambodia, Chile, China, the Democratic People's Republic of Korea, Ecuador, Egypt, Ghana, Guinea, Honduras, India, the Lao People's Democratic Republic, Lesotho, Mali, Mexico, Mongolia, Nicaragua, Nigeria, Peru, the Philippines, Senegal, Sri Lanka, Uganda, the United Republic of Tanzania, Viet Nam and Yemen.
- The World Bank manages an enormous volume of concessionary lending for rural electrification all over the world. In addition, the Bank manages some funds and implements several initiatives, such as the Lighting Africa initiative,[12] which aims to use high-tech compact fluorescent light bulbs (CFLs) and LEDs powered by renewable energy sources (e.g. solar and wind power and micro-hydro) and mechanical means (e.g. hand cranking and pedal power), to illuminate homes, businesses, health centres and other sites that are not connected to the power grid.
- *The World Bank's Climate Investment Funds* is the umbrella vehicle that distributes multilateral contributions to two trust funds and their programmes:
  - *The Clean Technology Fund,* which is open to projects and programmes that contribute to demonstration, deployment and transfer of low-carbon technologies with a significant potential for long-term GHG emissions savings. The energy sector, particularly renewable energy and energy efficiency in generation, transmission and distribution, figures prominently among the Fund's thematic priorities.
  - *The Strategic Climate Fund*, which contains the recently approved Programme for Scaling up Renewable Energy in Low Income Countries. Its aim is to shift generation of energy from conventional fuels, such as oil and coal, to renewable fuels.
- The *International Climate Initiative (ICI)* of the German Government is financed through the auctioning of Germany's allowable emission permits in the EU Emissions Trading System (EU ETS). A proportion of the revenues under the initiative is earmarked for sustainable energy projects in developing countries. It is currently implementing the project on climate-neutral energy supply for rural areas in India, and a CDM project for local electrification/replacement of fuel generators in villages and small towns in Burkina Faso.

Finally, 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. This group will promote public-private collaboration, seek ways to support small-scale power networks, and foster entrepreneurship, including local factories to manufacture fuel-efficient cooking stoves and energy services firms to provide small-scale electricity access for villages and micro-scale co-generation (G-8, 2009).

7. The Clean Development Mechanism

The Clean Development Mechanism (CDM) under the Kyoto Protocol 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 (60 per cent as at 1 July 2009[13]). It includes a sizeable number of registered and validated projects involving fuel switching and the deployment of RETs, some of which concern rural communities. 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 (IDCOL). 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).

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 to channel the distribution of investments much more to rural areas, particularly in the poorer developing countries such as those of Africa. The geographical distribution of CDM projects is currently heavily concentrated in a few large developing countries.

According to a World Bank report (2008c), sub-Saharan Africa has an enormous potential to absorb CDM investments, including in energy generation. If all CDM projects imagined by the authors of the Report were implemented, the result would be the addition of 170GW to this subregion's power generation capacity, implying a doubling of its current installed capacity. In order for Africa to be able to participate to a larger extent in CDM projects, the authors recommend the removal of barriers such as regulatory and logistic gaps in the energy markets, appropriate infrastructure planning, technical information on mature clean energy technologies and improvement of local skills for the design and implementation of projects.

Institutional capacity is particularly important to link RET-based electrification opportunities with the CDM. Authorities and firms may lack the capacity to identify opportunities, elaborate CDM project documents in line with UNFCCC Executive Board requirements, and implement project activities leading to the certification of tradable certified emission reductions. A good starting point would be for developing countries, particularly in Africa, to include rural electrification objectives in their national appropriate mitigation action plans (NAMAs) and in their national adaptation programmes of action (NAPAs). Renewable energy and rural electrification projects have so far been given relatively little importance in NAPAs, even though the implementation of all or most other listed priority projects requires the utilization of energy.[14]

F. Conclusion

The widespread deployment of renewable sources of energy is not only an environmental and developmental imperative; it can also be strategic in multiple ways. The electrification of poor rural communities constitutes a prerequisite for poverty reduction and development. However, investing in energy utilities alone will not suffice to spur a sustainable economic growth spiral. Incorporating access to energy in rural poverty alleviation strategies can only be sustained if it offers income-generating opportunities and improves the welfare of the rural poor.

Rural electrification based on RETs is not a new concept; several programmes are already being implemented in many developing countries. The bulk of electrification projects financed by the World Bank today are based on RETs. However, the concept has been given renewed political and social impetus due to the current environmental, economic and food crises. Seizing this momentum to lock in development spirals based on sustainable sources of energy necessitates local, national and global mobilization. Action is needed in particular to multiply projects, make finance available and remove barriers which hinder such investments. This highlights the prominent role that must be played by actors that are able to promote knowledge-sharing and serve as clearing houses to link investors with investment opportunities.

A national strategy for the upgrading of RET-based rural electrification could comprise some of the following elements:

- Incorporate universal access to energy services and rural electrification in national development strategies and poverty reduction goals, utilizing PRSPs or NAPAs if appropriate;
- Support and coordinate rural electrification objectives with environmental sustainability goals, particularly those related to climate change mitigation and adaptation, to promote renewables as a strategic tool.
- Draw on road-mapping and other analytical exercises to assess and identify clean technology needs and opportunities at the national level, considering the full range of technology options, and not limiting objectives to only PVs or any other single RET.
- Assess the individual contributions of such technologies to national energy security at various levels, and to economic development and reductions in GHG emissions.
- Identify pockets of opportunities, both on the demand side (productive activities such as manufacturing of energy systems) and on the supply side (e.g. fostering the emergence of energy businesses). Identify possible synergies with other policies or public investments (e.g. opportunities to bundle public services or to equip public buildings with RETs).
- Estimate the development and deployment costs of such technologies in major sectors (power generation and transmission, appliances, buildings, transportation and industry).
- Prioritize investments in rural regions that offer good prospects to run pilot projects (e.g. good employment and productive potential, known availability of natural resources). Foster cooperation among government agencies and ministries (multisectoral approach), identify opportunities for service bundling, and facilitate the emergence of innovative supply models (concessions, village or women's cooperatives, public-private partnerships).
- Identify partners (for the financing, design and implementation of projects) as well as intermediaries that could mobilize and raise awareness among local communities. Identify and exploit multi-stakeholder platforms at the regional and international levels for providing advice on appropriate RET deployment strategies in combination with job- and income-generation programmes.
- Assess financial needs and identify a menu of options for support (e.g. subsidies, microcredit, loans, partial guarantees and revolving funds). Combine financial support with consumer education, and managerial and technical capacity-building.
- Devise concrete steps for implementing such policies, including through appropriate international collaboration and domestic reforms, monitoring progress during and after implementation.
- Identify domestic institutional gaps (e.g. lack of rural electrification agencies and/or regulatory bodies), and regulatory and financial barriers that hinder the adoption of RETs in general, and in the context of rural investments in particular.

Finally, an important element is to continue developing tools to identify, quantify, foresee and monitor the development impacts of rural energy projects. The poverty and gender impacts of rural electrification investments have been poorly integrated into projects so far, and while the poorest households tend to benefit from electrification as coverage expands, effectively reaching the most vulnerable remains a priority. Indeed, the introduction of new technologies and the promotion of income-generating opportunities can create or exacerbate social fragmentation. Truly bottom-up and participatory approaches are therefore crucial.

II. Combining Climate Change Mitigation Actions with Rural Poverty Reduction: DESI Power's Employment and Power Partnership Programme

Dr. Hari Sharan
Chairman, Decentralised Energy Systems India Ltd (DESI)

» DESI Power's EmPower Partnership Programme is an initiative that seeks social investment for a decentralized, biomass-driven electrification programme in rural India. Pilot projects already implemented illustrate how investments in electrification can and should be utilized to promote the emergence of local sustainable markets and microenterprises.

» The key is to adopt a global approach which seeks the highest possible social, environmental and financial returns on investments through the generation of self-sustained sources of revenue. For instance, energy and utility services (lighting, water for drinking and irrigation, and energy for cooking) and microenterprises are created simultaneously with the power plant. Supporting finance can be found in a combination of a government subsidy, revenues from the selling of CDM credits, soft loans from private investors, commercial project loans, and grants. The scheme is completed with capacity-building and training of local partners and microentrepreneurs to manage and run the plants and use energy efficiently for sustainable productive uses and income generation.

» The combined economic, social and environmental returns from such integrated projects make them one of the most cost-effective instruments for poverty reduction in rural villages.

A. Background

1. Access to electricity in rural India

It is commonly acknowledged that inadequate and unreliable electricity and modern energy supply services are among the main causes of the lack of progress in India's rural areas. No non-traditional productive activities are possible without those services. The record of the last 50 years of rural development therefore reinforces the special relevance of Gandhiji's vision of self-reliant villages – a vision even more valid today than it was during his lifetime for the following reasons:

- It has become painfully evident during the past decade of liberalization that it is difficult to mobilize the enormous amounts of capital required for large power stations to supply fossil-fuel-based electricity within the foreseeable future to every Indian, to every large and medium-sized industry, to new rural microenterprises, to the agricultural sector and to urban and rural public services.
- It is also clear that the present centralized system is very largely dependent on coal, which is CO_2-intensive and accelerates climate warming.
- Yet modern, mature, renewable energy systems are available now, and can supply reliable and affordable electricity, irrigation water and energy services at prices which are competitive with non-subsidized conventional fossil-fuel-based grid supplies and captive generation.
- Many more technological solutions for local value addition through small-scale industries in villages are available today. A host of traditional and new agro-based industries and microenterprises would be able to operate profitably in villages if they had access to reliable electricity supply.
- Local value addition of local resources, increased farm productivity and "export" of traditional and new products and services to nearby urban and peri-urban areas will promote faster economic growth and create local employment in villages. One such example is the supply of modern, village-processed cooking fuel based on agro-residues to replace fuel wood and fossil fuels.
- Production of goods and services will increasingly become an alternative to the poverty-driven migration of village youth to city slums.
- The costs of investments can be moderate or even negative. Apart from symbolic investment by local people, selling certified emission reductions (CERs) under the Kyoto Protocol's Clean Development Mechanism (CDM) will leverage local and external private sector investments if the projects are seen to generate profits and jobs.
- The Government needs to establish a framework of incentives, laws and regulations for large-scale

Table 5. Cost of supplying power to a village (Rs million/megawatt, MW)

	Generation		Transmission and Distribution Losses		End-use energy	
	MW	Cost	MW	Cost	MW	Cost
Centralized grid supply	1	35	0.3	5	0.7	57
Decentralized biomass power plant (gasification)	1	35	0.1	5	0.9	44

Source: Internal Report, DESI Power, 2005.

implementation of the model and to garner support from the commercial banking system.

- The liberalized economic regime and the political framework of village *panchayats* (local governments) should enable the Government to promote a long-term public-private partnership model for the financing of projects, such as the EmPower Partnership Programme.

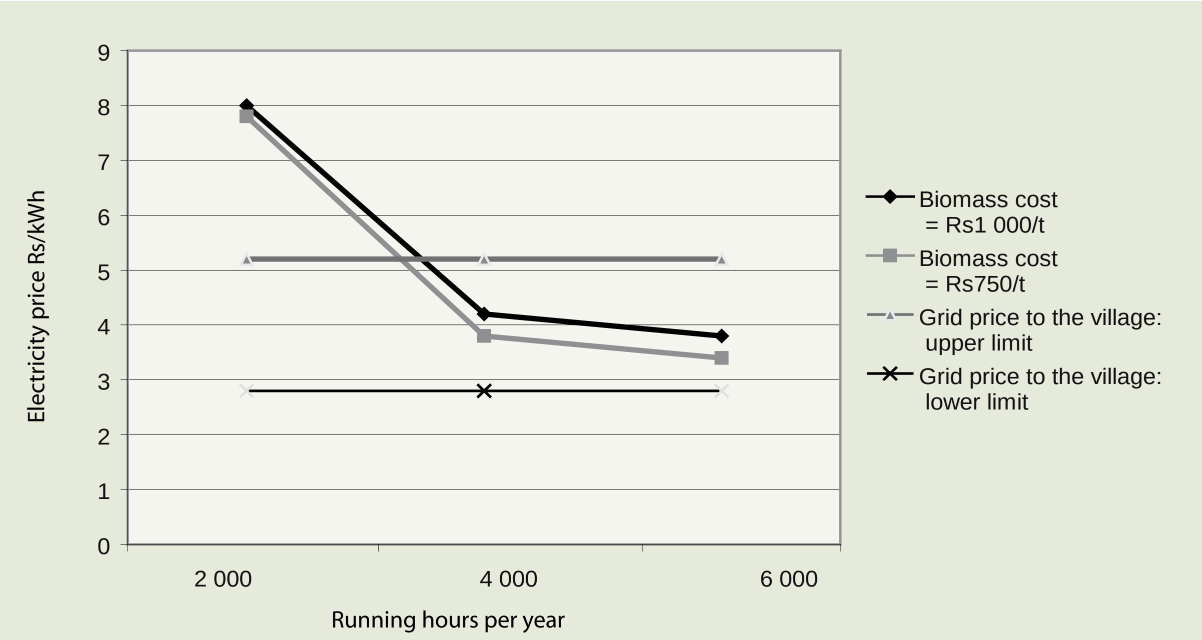
2. Financial advantages of decentralized biomass power plants

Of the more than 500,000 villages in India, about 310,000 have been declared already electrified. According to government statistics, 80,000 more villages remain in need of electrification. The state governments were directed to take up the electrification of 62,000 villages by 2007 through their electricity boards under the traditional rural electrification programmes. The Government of India has also directed the Ministry of New and Renewable Energy (MNRE) to provide renewable-energy-based electrification to 18,000 villages in remote and inaccessible parts of the country by 2012.

In actual practice, however, most of the so-called electrified villages do not have reliable, adequate or good quality power. No commercial investments in micro-enterprises can therefore be made by either individuals or companies without installing diesel generators, which have a very high generating cost, create adverse environmental and climate impacts, cause high foreign exchange outflows and reduce the country's energy security.

As the experience of DESI Power's EmPower Partnership Programme shows, grid supply to remote areas is not competitive with electricity supply from modern, decentralized renewable energy power plants, either

Figure 2. Price of electricity in a village with pure producer gas engine and grid supply



Source: Internal Report, DESI Power. 2005.

in terms of supply or at the end-use point (table 5 and figure 2 showing 2005 data, but trend is still valid). Decentralised power supply (biomass plant) saves power (smaller losses), costs, and CO_2 emissions.

B. The EmPower partnership programme

1. A 100-village commercial demonstration programme for EmPower partnership projects

In absolute terms, the proposed programme, with its goal of installing 5–7.5 MW of generating capacity, is puny compared with the planned installation of 5,000–10,000 MW of generating capacity per year in the conventional fossil-fuel-based power sector in India. However, the project is complex in the context of the many undeveloped rural areas that lack power or other infrastructure and the large number of diverse stakeholders (table 6). DESI Power's experience shows that any centralized system – be it the Government, the private sector or NGOs – will find it very difficult to implement a decentralized programme successfully and efficiently. Therefore, decentralized implementation is planned jointly with villagers, local organizations and entrepreneurs, NGOs, plant promoters, suppliers and builders, financiers and corporate entities.

Based on their experience of the past 15 years, DESI Power and its partners are convinced that centralized electrification alone will neither make electricity supply profitable nor promote the economic and social development of remote villages in India. However, for renewable-energy-based rural electrification to succeed without perpetual subsidies and losses, it is essential to satisfy two critical conditions of power supply and local demand/load:

i) An adequate number of microenterprises should buy enough electricity to enable the supply of that electricity to be commercially viable.

ii) Adequate amounts of affordable and reliable electricity should be locally available, not only for domestic lighting and cooking but also for local microenterprises and water pumping.

Self-sustained growth can take place if the rural electrification programme is linked to village microenterprises for local value addition and employment generation. The power generation based on local renewable energy resources can provide reliable and affordable electricity supply to make the microenterprises profitable, and thus bankable and attractive for private entrepreneurs. Biomass, biogas, solar thermal and PV will be the prime sources of renewable energy in a large number of villages, perhaps more than 300,000, which at present have no access to electricity.

These conditions can be met if the other government programmes on rural job creation and rural small-scale industries are implemented simultaneously in an integrated manner with the Government's programme on renewable-energy-based rural electrification. The EmPower Partnership Programme is structured to ensure that these conditions are met.

The programme could be accelerated if:

- Government support and budgeted public funds are leveraged to obtain local, private and corporate sector investments in these rural projects.
- A policy framework can be established for utilizing sanctioned funds earmarked for renewable-energy-based rural electrification as well as for other rural development programmes (e.g. schemes for promoting small-scale industries, job creation, etc.) in a more focused and integrated manner.
- A policy framework also provides incentives and regulatory support to the private sector to start a programme for the large-scale replication of models such as the EmPower Partnership Programme.

Table 6. The EmPower partnership framework

DESI Power, Development Alternatives/Tara + other companies	Village partner organization(s) (i.e. local village team)	Investors, banks, grants, subsidies, selling CO_2 emissions savings
EmPower Partnership for Village Development		
Independent rural power producer Provision of electricity and energy services	**Village enterprises** Water supply, agro-processing, small industries, fuel supply and processing, agro-forestry, workshops.	**Cluster centre** Organization and project development, training, extension services and refresher courses.

Figure 3. Activities under the 100-Village EmPower Partnership Programme

The Indian 100-Village EmPower Partnership Programme

Decentralized EmPower village projects:

- 10 Clusters with plants in neighbouring villages with a total of about 500 kW each
- Identification, organization and training of promoters / owners of each village plant
- Support for plant construction
- Cluster development
- Cluster management

Financing:

- Government subsidies and loans
- Equity: local and external.
- Commercial loans
- Grants
- CDM: sale of CO_2
- Fund management

Capacity-building/extension services

- Initial capacity-building and orientation for project development
- Technical and managerial training of local trainers, managers and staff
- Training tools for local refresher courses
- Women's capacity-building
- Performance audit and continuing support services

2. Climate change mitigation impact

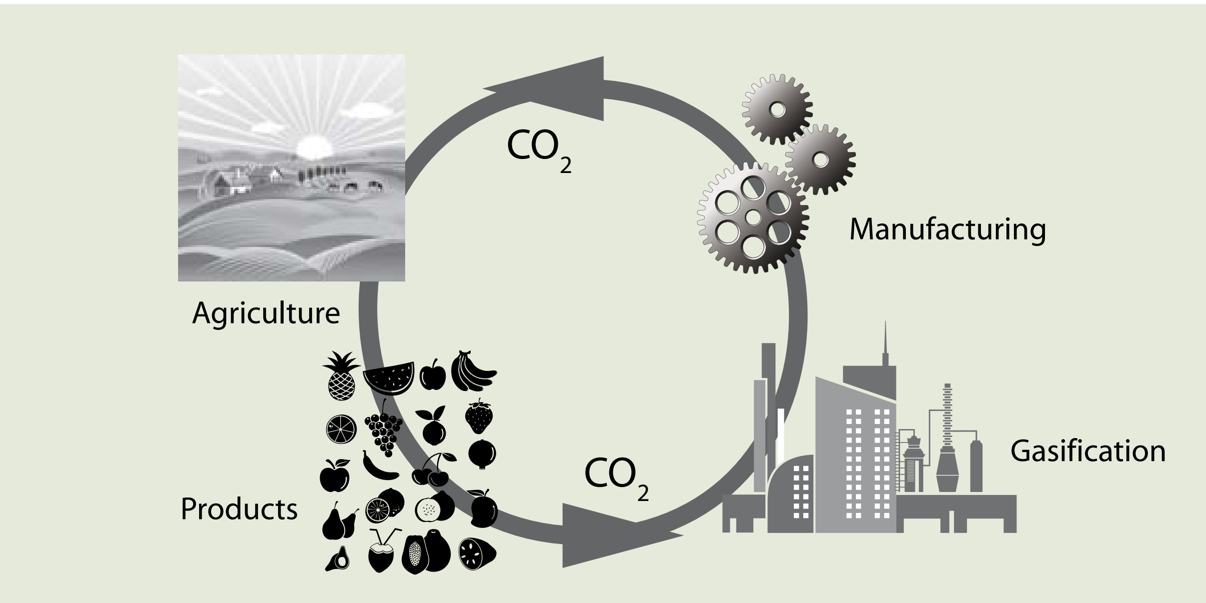
The Partnership Programme will generate savings in CO_2 emissions which will be an additional gain for the global community and an additional source of funding for EmPower Partnership Projects for providing start-up capital for poor villagers.

3. Start of the EmPower Partnership Programme

Decentralised Energy Systems (India) Pvt. Ltd. launched its 100-Village EmPower Partnership Programme for Araria District in the state of Bihar in February 2005. Its objective was to link 100 small biomass-gasifier-based power plants to energy services and microenterprises, all owned by village cooperatives (figure 3). These 100-kW plants were each expected to create at least 50 direct and indirect jobs in each village and eradicate poverty in the participating families. Since the launch, projects have been completed and operational in three villages. Technologies, processes, microenterprises and management systems used in these first three villages comprise:

- Biomass-gasification-based power plants with pure gas engines
- Water pumps for irrigation replacing diesel pumps
- Battery charging

Figure 4. The CO_2-neutral cycle for biomass gasification power plants



- Mini-grids with connections to each household in each village, replacing kerosene
- Traditional agro-processing units (husking, milling, etc.), replacing diesel
- Battery-run LED lighting charged by the power plant or solar PV panels, replacing kerosene
- Biomass processing (cutting, drying, briquetting) and management
- Energy plants and vermiculture
- Fisheries

Financing for these projects was obtained from multiple sources, including:
- Equity from local partners who formed cooperatives and societies for this purpose.
- DESI Power loan and equity from promoters and external “socially responsible” investors.
- World Bank Market Place Award 2006.
- Tech Award 2008.
- Up-front selling of CERs.
- A grant from the International Copper Association for the mini-grid.
- A loan from a foundation run by an Indian commercial bank.

Table 7. Total investment in the EmPower Partnership Project with a 75-kW installed capacity

Description	Amount (Rs million)
Total energy services, microenterprises and infrastructure	3.3
Total power plant	4.5
Project development and implementation, including coordination and travel, capacity-building, training and a cluster centre	0.8
Total investment for one village EmPower Partnership project	**8.6**

While the investment needed for one typical EmPower Partnership project based on biomass processing, a power plant, energy services and microenterprises will vary from village to village, depending on the microenterprises involved, a typical average amount will be about Rs 8.6 million (about $175,000) per village (table 7). Funding required for one cluster consisting of 10 villages is Rs 86 million ($1.75 million), the total for the entire programme of 100 villages being Rs 860 million ($17.5 million).

Table 8 below shows one model of financing such projects, combining multiple funding sources. 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 they would be prepared to consider 50–60 per cent of the project cost as a loan if the other funds are assured.

Depending on the success of the commercial demonstration phase of 100 villages, replication is expected with a government framework of incentives, checks and balances to ensure that the social and environmental objectives will also be achieved. Viewed in terms of the national economy, EmPower Partnership Projects in 10,000 villages would result in a total installed capacity of 500 MW and a total saving of Rs 6,500 million ($144 million) on the conventional power supply side. Since the projects will be profitable, it might be possible to raise 30–70 per cent of this capital from direct private sector equity and loans. If the Government provides a suitable framework, ethical foreign direct investments are likely to flow to these projects, especially if they are bundled and promoted as public-private partnership schemes. Since these projects are recognized as premium CDM projects, up to 30 per cent of capital could also be raised by selling CO_2 savings. Government subsidies for rural electrification may bring another 10 per cent, and the remaining amount could be raised as loans from development banks (such as the Indian Renewable Energy Development Agency (IREDA), the Small Industries Development Bank of India (SIDBI) and the National Bank for Agriculture and Rural Development (NABARD)) or from commercial banks.

The profitability of EmPower Partnership projects (Table 9) will improve as more and more projects are built incorporating modifications in planning and implementation as a result of lessons learnt. Lessons

Table 8. Likely sources of investment

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

Table 9. Profitability of a pilot phase EmPower Partnership project (with an adequate number of business units and a medium plant load factor)

Based on actual data for each business unit (BU)	Pure gas engine 12 hours/day
Investment for business units (considered as a loan) (Rs)	1 143 714
Annual interest rate (%)	12
Capital repayment period (years)	8
Annual capital service rate (%)	20.1
Annual capital service payments, BU (Rs)	230 000
Annual profit of BU (after meeting capital service payments and overheads) (Rs)	120 770
Annual profit of BU (after meeting capital service and overheads (% of income)	10.56
Investment, power plant (Rs)	2 326 313
Annual profit of power plant (Rs)	116 316
Profit of power plant (%)	5
Total investment in BUs and power plant (PP) (Rs)	3 470 027
Total annual profit from EmPower Partnership project (BU+PP) (Rs)	237 086
Return on investment for total EmPower Partnership project (%)	6.8

learnt in the pilot projects lead to the reduction of costs achievable by value engineering and standardization as well as from the use of energy-efficient equipment in microenterprises and energy services. Some of the other essential ingredients of success are:

- Institutionalization of training and capacity-building of a large number of local people for the management teams and operational staff.
- Proper selection and mix of microenterprises and products to match local resources and market requirements.
- Higher investment in micro enterprises.
- Promotion of agroforestry and energy plantations.
- Offering of more energy and utility services.
- Maintaining a high power plant load factor.
- A profit-oriented financing model with easy access to equity, loans and subsidies until such time as hidden subsidies for fossil fuels are eliminated.

The first batch of projects under the EmPower Partnership Programme are now operational in three villages (three units are registered under the CDM) under commercial demonstration conditions. The second batch of 20 EmPower Partnership projects in 20 villages is ready to start. Based on learning from the first batch and their investment and operational data, a business plan for the second batch has been finalized. Figure 5 below shows one set of projected results for a typical case, with investments in the form of equity, loans and subsidies. In this case, the income from selling the resulting CERs under CDM is considered as an annual income stream. Issues related to depreciation and taxes will be clarified jointly with the equity investor once the current discussions are completed.

4. The triple return-on-investment criteria for evaluating and financing the EmPower Partnership Programme

One of the axioms of the neo-liberal economic thinking is that investments must be justified on the basis of an adequate return on investment (ROI) to attract private sector operators. Issues related to fairness and equitable sharing of common resources, external costs and long-term damages caused by economic activities carried out for private profit, and the short- and long-term monetary costs of social unrest are not taken into account in such investment decisions. One of the hardest tasks of those involved in promoting sustainable development is to try and convince policy-makers, private sector investors and financial consultants that ROI as the sole criterion is not adequate for programmes covering sustainable energy, economic and social rural development and poverty reduction. Economic, social and environmental consequences should all be considered in making investment decisions and selecting projects, and a single "triple ROI" criterion should be used for this purpose.

Figure 5. Profitability of EmPower Partnership Projects (with the total planned investment in business units to ensure high plant load factor)

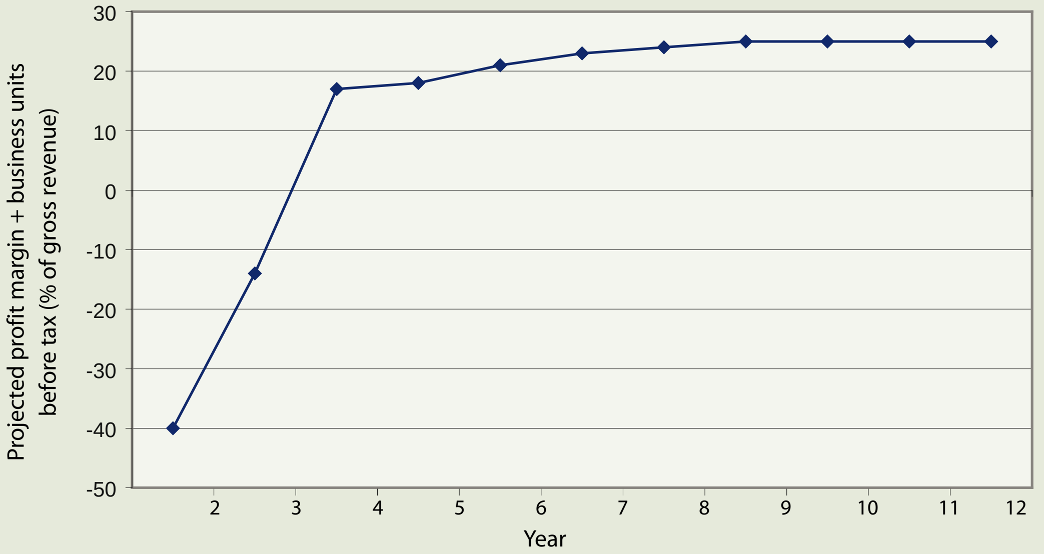


Table 10. Typical performance of a pilot EmPower Partnership project (with a low plant load factor)

	Economic performance		Social				Environmental		
Machine/ plant	**Investment (dollars)**	**ROI (profit as % of investment)**	**Total direct jobs created**	**Invest-ment per job ($/job)**	**Jobs for women**	**Other impacts[a]**	**Reduction of local pollution[b]**	**Savings in CO_2 emissions**	**Cost of savings of CO_2 emissions**
Briquetting machine 125 kg	9 000	6.0	2.1	4 286	Yes	Yes	Yes	Yes	Much lower than in industrial-ized countries
Four new pumps	8 000	17.0	1.1	7 273	Yes		Yes	Yes	
Old pumps	1 000	51.0	1	1 000	Yes		Yes	Yes	
Paddy processing	30 000	8.0	5.5	5 455	Yes	Yes	Yes	Yes	
Fishery	3 000	15.0	1	3 000					
Tree planting	5 000	3.5	1.5	3 333	Yes		Yes	Yes	
Power plant	60 000	10.0	5	12 000			Yes	Yes	
Other small energy service units	10 000	10.0	2	5 000	Yes	Yes	Yes	Yes	
Project total	**126 000**	**9.8**	**19**	**6 563**					

[a] Other social impacts cover drinking water, lighting, cooking, health services, schooling and capacity- building.
[b] Local pollution covers impacts on air, water and soil.

The EmPower Partnership Programme promotes projects which combine social and environmental benefits with a fair financial return (table 10). The 100-village programme will create more than 2,500 direct, year-round jobs, in addition to several indirect jobs, through increased farm production, new trading and commercial activities and energy services. It will also reduce pollution, improve women's health and reduce rural migration to city slums. Overall, the growth of the gross national product (GNP) as well the Human Development Index of the village can be quantified and demonstrated for large-scale replication of the EmPower Partnership model.

C. Conclusion

DESI Power's EmPower Partnership Project seeks social investment in the rural development marketplace under a model of public-private partnership. The EmPower Partnership Project is positioned to create local sustainable markets for decentralized power supply, energy services and microenterprises in Indian villages. Led by a network of social entrepreneurs and supported by a public-private network of partners, the project is designed for successful revenue-based financial, social and environmental returns on investment.

A government subsidy, combined with the selling of CDM credits (or credits under many existing voluntary carbon offset schemes) will provide the start-up capital – a "leveraging" component of the required investment – together with a small equity funding by the villagers. Combined with external equity and soft loans from private sector ethical and/or other investors, commercial project loans can be raised from development and commercial banks. Grants complete the scheme, particularly to cover the costs of capacity-building, training and the initial running costs.

The combined economic, social and environmental returns from projects such as the EmPower Partnership Programme make them one of the most cost-effective instruments for poverty reduction in rural villages. Overall, the growth of the GNP or GVP (gross village product) as well of the Human Development Index of the village can be quantified and demonstrated for large-scale replication of the EmPower Partnership Programme's pilot projects.

III. Powering the Green Leap Forward: China's Wind Energy Sector

Dong Wu
UNCTAD secretariat

» China has recently emerged as a global leader in wind energy industry, more than doubling its overall capacity every year since 2006 to reach an installed capacity that is second only to that of the United States.

» In addition to this impressive growth in installed capacity, China's real success concerns the emergence of a competitive local industry producing high-calibre windmills based on local research and technology.

» China's successful experience can be explained by several factors. First, a highly favourable wind energy potential. Second, supportive and flanking government policies promoting renewable energy sources (feed-in tariffs, local content requirements, tax rebates, financial support to research). Third, corporate strategies to bridge the technology gap, particularly focusing away from licensing and preferring the commissioning of original constructions delivered by international design and consulting firms. Fourthly, initiatives to foster synergies in the supply chain though the creation of local technology and industrial clusters/parks..

In recent years, China has emerged as a global leader in wind energy, more than doubling its overall capacity every year since 2006. In 2008, China's newly installed capacity amounted to 6 GW, while its cumulative installed capacity was more than 12 GW and set to rise to 20 GW by 2010 (compared with India's cumulative installed capacity in 2008 of 1.8 GW). This will make China the second largest producer of wind energy in the world after the United States, overtaking both Germany and Spain.[15] Projections are that China will reach 30 GW installed capacity by 2011 – well ahead of the target year 2020 originally set by the Government. For Chinese experts, these developments mark the beginning of "a golden age of wind power development" in the country.

However, installed capacity, is only half of China's success story; the other half is the emergence of a competitive local industry. Until recently, China relied largely on foreign companies to supply much of the equipment for its rapidly growing number of wind farms. Although there were several domestic companies manufacturing turbines, their output lagged significantly behind their main foreign competitors. Until two years ago, none of the Chinese manufacturers were capable of producing megawatt-class wind turbines (Schwartz and Hodum, 2008). Some key components such as bearings (used in gearboxes) and control systems had to be imported, since domestic suppliers lacked the necessary capabilities to produce them. Today, the situation has fundamentally changed: a number of Chinese turbine manufacturers have successfully closed the technological gap with their European and American competitors and now dominate the domestic market. Domestic manufacturers accounted for 70 per cent of newly installed capacity in 2008, up from 30 per cent in 2004. Goldwind and Sinovel, China's leading turbine manufacturers, already rank among the top 10 manufacturers in the world; Dongfang, Windey and several others are likely to follow. China's wind generator industry has also made significant progress in developing and building up an indigenous supply chain that links turbine manufacturers, component suppliers and technology services (He and Chen, 2009). A prominent example is China High Speed Transmission Group, which, within a relatively short period of time, has established itself as the major supplier of high-quality gearboxes, not only for the domestic market but also increasingly for the international market (Beijing Gao Hua Securities Company Ltd, 2009). As a result, China is poised to become a major player in the global wind power equipment market within the next few years.[16]

Several factors have contributed to the rapid expansion of the Chinese wind power sector since 2006, not least China's highly favourable wind energy potential. According to a recent *Science* article, if China were to take full advantage of its wind potential, wind power could meet the country's entire demand for electricity by 2030, generating close to 7 trillion kWh of energy per year, and thus contributing significantly to the country's energy security (McElroy et al. (2009). However, favourable environmental conditions do not necessarily guarantee their exploitation. Three additional factors have been particularly instrumental in forcing China's recent wind power push: government policies promoting renewable energy sources, corporate strategies to bridge the technology gap, and local government initiatives to establish technology clusters that benefit the wind industry. These are discussed below.

A. Public policy

Government policies have played a decisive role in the rapid development of the country's wind energy sector. None has been more important than the Renewable Energy Law, which came into effect in 2006. The law and its implementing regulations not only confirmed the Government's commitment to the development of renewable sources of energy within Government-set targets, but also reaffirmed its commitment to provide special funds and offer financial incentives to the renewables sector to meet those targets. The goal of these policies, according to the Medium and Long-Term Development Plan for Renewable Energy of 2007, was to establish a "basic system of renewable energy technologies and industry" by the year 2010 as a foundation for the development of "relatively complete", large-scale domestic manufacturing capabilities, primarily based on China's own intellectual property rights (NDRC, 2007). In support of the policies, the National Development and Reform Commission (NDRC) and the Ministry of Science and Technology (MOST) have provided strong support to the wind sector. The development of wind technology has been accorded a prominent place in the nation's major research programmes, most notably the national basic research programme, national high-tech R&D programme, and the national key technology R&D programme. In addition, NDRC and MOST have provided financial support through dedicated R&D funds for renewable energy (Zhang et al., 2009; Lee and Ma, 2009).

Most important of all for the wind energy sector, the Government required grid companies to provide access to the local grid and offer ancillary technical services to wind power projects, as well as to purchase the full amount of energy generated by them. However, the law did not alter the wind concession system for large-scale wind farms and replace it with a feed-in tariff. Under the concession system, wind project developers engaged in competitive bidding; the winner received guaranteed long-term power purchase agreements from the grid operator. The model tended to award those developers, which offered the lowest feed-in prices. Generally, these were large State-owned energy companies eager to meet the Government's clean energy quotas, and which could offset losses incurred in the wind sector with profits made from traditional energy (i.e. coal and hydro) sources. The concession system was abolished in August 2009 and replaced by a conventional feed-in tariff model.

In order to promote China's emerging wind industry, the Government introduced a number of regulations and incentives to support domestic manufacturing capabilities. As early as 2003, the Chinese authorities mandated local content requirements, first amounting to 40 per cent in the context of the concession programme, subsequently raised to 70 per cent, and extended to all new wind installations, including those applying for financing under the Clean Development Mechanism (CDM)financing. The Government also used tax policy to steer the wind power sector in the desired direction. In 2001, for instance, the value-added tax for wind power was cut in half (from 17 to 8.5 percent); there was also a shift in customs policy. Initially, imported wind power equipment was exempted from customs duties in order to promote technology transfer. Subsequently, as the focus increasingly shifted to the development of a domestic wind power manufacturing base, the government issued graduated customs duty rates that favoured the import of components over complete turbines (Zhao, Hu and Zuo, 2009, p.2888). Once Chinese companies had mastered megawatt-level turbine technology, the Government modified the policy. In April 2008, the Ministry of Finance announced the removal of all tax breaks on imported wind turbines below 2.5 MW (Ministry of Finance, 2008). At the same time, the Government announced a VAT rebate on imported "key components and raw materials" if they were used by domestic manufacturers to develop and manufacture large systems (1.2 MW and above). The returned taxes were to be used to support "new product development and innovation capacity building" (Ministry of Finance, 2008). In August 2008 the Ministry of Finance issued a second financial incentive package aimed at promoting domestic wind power equipment manufacturers. The policy rewards domestic manufacturers with 600 RMB per kW for each of the first 50 turbines of over 1MW, if they have been tested and certified by the Chinese authorities, put into operation and connected to the grid. Only those turbines qualify that use domestically produced components. Experts expect this policy to have a "significant impact on the future promotion of China's domestic industry's technology innovation, improving competitiveness and building domestic branding in the long run" (Global Energy Council, undated).

B. Enterprise strategies

Initially, Chinese turbine producers acquired licenses from foreign companies to reproduce existing turbine designs. This allowed them to get established in the domestic market and gain experience in the production of larger turbines. However, the Chinese manufacturers soon found out that foreign firms were reluctant to license their most recent, state-of-the art technology; instead they preferred to license turbines that were technologically outdated for fear that the transfer of advanced technology would lead to knowledge spillover, thus undermining their competitive advantage (Liu, 2006). Licensing thus soon proved to be insufficient, particularly given the ambitions of the Chinese wind energy programme, which aimed largely at the commissioning of large-scale wind farms employing megawatt turbines (1.5 MW and higher).

In response, major Chinese turbine manufacturers changed their strategy. The focus shifted away from licensing to the commissioning of "original constructions" delivered by international design and consulting firms. This has had two advantages: first, the cost of design tends to be substantially lower than licensing fees (one third, according to one Chinese expert); second, in general, once the design firm has delivered the blueprint, the Chinese client owns the intellectual property rights to the design. This strategy has allowed even newcomers to leapfrog years of wind technology development, produce relatively advanced, high-capacity machines, and thus compete with the established and more experienced domestic enterprises such as Goldwind and Sinovel (Liu, 2006).

In each of these stages, the role of German firms has been crucial. Goldwind, for instance, China's "oldest" and most experienced turbine manufacturer got started buying a licence from the German firm, Jacobs Energie (today part of REpower Systems) for a 600-kW machine. Six years later, Goldwind entered the 1 MW market by purchasing a licence from Vensys Energiesysteme, a relatively small company based in Saarbrücken, for its 1.2 MW turbine. Meanwhile, Goldwind acquired a 70-per cent share in Vensys, which has been working together with experts from the Saarland University of Applied Sciences on a 2 MW and 2.5 MW turbine for Goldwind. As a result, Goldwind has gone from "licensee to market leader" (Jensen, 2008). Other leading turbine makers, such as Sinovel and Dongfang, followed Goldwind's lead, acquiring licences from Fuhrländer and Repower respectively.

The recent shift in strategy has particularly benefited relatively small engineering and design firms, such as Aerodyn (Germany) and Windtec (Austria, a subsidiary of American Superconductor). Although Aerodyn has also sold licences (e.g. for its rotor blades), its main focus is on consulting and design. As such, Aerodyn has been instrumental in the emergence of a number of new wind energy firms in China's domestic market, such as MingYang Wind Power Technology, which entered the market with a versatile 1.5 MW turbine in late 2007, and Sewind, which in 2008 concluded a joint development agreement with Aerodyn for a 3.6 MW machine due to be delivered in late 2010 (May, Weber and Weinhold, 2008). MingYang and Sewind, like a growing number of other recent newcomers to the Chinese wind energy market, are subsidiaries of large established enterprises which have gained their reputation in the fields of mechanical engineering, tool making, and/or energy-related equipment manufacturing. These companies have built up considerable technological and engineering capabilities, which they could apply, at least in part, to the wind energy sector. Particularly for these companies, engaging the services of established design firms has been a logical step in their corporate strategy.

Established manufacturers, confronted with this new trend in wind technology acquisition, have followed suit. At the same time, however, they have started embracing a new strategy, in line with a new trend in thee global wind industry. As Andrew Garrad, chairman of the British energy consulting firm Garrad Hassan, has recently noted, in the past, the main objective was to develop "bigger and bigger" turbines in order to extract ever more power from the available wind resources. Today, however, the emphasis is increasingly on "better and better". This implies, according to Garrad, "diversifying to produce different wind turbines to cope with more specific site characteristics" (*New Energy Focus*, 2009). A case in point is Dongfang's cooperation agreement with the Finnish company, The Switch, from early 2008. Under the agreement, The Switch will supply Dongfang with the production concept and technology for its innovative "permanent magnet generator" product package, which, according to experts, represents "the technology of choice for next-generation wind power generators, as they offer a platform of highly integrated components that are built to last and require very little maintenance."(*Penn Energy*, undated).[17] Similar considerations appear to have been behind Sinovel's cooperation deal with American Superconductor Corporation (AMSC). Under the agreement, Sinovel will have access to AMSC's core electrical components, particularly its state-of-the-art power converter which, according to AMSC sources, enables "reliable, high-performance wind turbine operation by controlling power flows, regulating voltage, monitoring system performance and controlling the pitch of wind turbine blades to maximize efficiency" (Finanzen Net, 2009). Goldwind's recent partial acquisition of the German turbine developer Vensys was similarly motivated by the desire to improve the product quality of China's leading turbine manufacturer.

C. Technology clusters

For the Chinese wind energy industry to meet the Government's ambitious targets, the development of a reliable supply chain based on indigenous R&D is of crucial importance (He and Chen, 2009: 2897). One way to foster R&D in a particular technology area is to concentrate technology firms, suppliers, and ancillary services in spatially circumscribed technology clusters (a sort of dedicated industrial park) (Porter, 2000). To a certain extent, this has happened in the Chinese wind energy sector. At present, there are at least three major local clusters, all of which are located in special economic development zones in large cities in the north-eastern part of the country: Tianjin, Baoding and Shenyang. Each one houses a mix of domestic and foreign turbine manufacturers, component suppliers and technology services.

Tianjin's wind energy cluster is located in the Binhai Hi-Tech Area, which is part of the city's Hi-Tech Industry Park (established in 1991). This cluster is home to three leading foreign turbine manufacturers (Vestas, Gamesa, and Suzlon, since 2006), in addition to the blade manufacturers, LM Glasfiber (the world leader in rotor blades from Denmark, in Tianjin since 2001) and Tianjing Dongqi Wind Turbine Blade Engineering (2007), as well as Tianjin Dongqi Wind Turbine Technology (2008). Tianjin is also home to Winergy Drive Systems (owned by Siemens), a leading supplier of gear units and complete drive systems for wind turbines, located in Beichen Economic Development Area, which is adjacent to the Binhai Hi-Tech Area. The most recent addition to the growing number of wind energy-related companies in Tianjin is Hexcel, a leading world supplier of specialized composites for rotor blades, which followed Vestas to China (Gardiner, 2008).

According to official sources, the target for the wind energy sector in Tianjin is to establish the city as China's largest wind energy equipment manufacturing base as well as a main centre for R&D, consulting, training, and certification and evaluation. Above all, the Tianjin Hi-Tech Area is supposed to become a major source of innovation in the green energy sector. In order to achieve this goal, the local government provides a panoply of financial incentives, ranging from subsidies for land and building rents as well as for the interest paid on loans, to direct financial support for institutions involved in R&D for the wind energy sector (and other high priority hi-tech sectors) (Liu, undated).[18]

Like Tianjin, Baoding has ambitious plans with regard to the wind energy sector (Delman and Chen, 2008; Koot, 2006; Reinvang, 2008).[19] A Hi-Tech Development Zone was established early in this decade. In 2003, it was declared a "State New Energy and Energy Equipment Industrial Base" by MOST. In 2006, the municipal government set out to turn Baoding into "China's Electricity Valley" centred around the renewable energy sector (wind and solar). The target was to increase, within a period of five years, turbine production to 1.5 GW and rotor blade production to 2.4 GW. In addition, the plan was to attract a range of component manufacturers and R&D facilities. In order to achieve these goals, the administration of this hi-tech zone created a number of incentive programmes to facilitate access to risk capital, and established special funds to support technology development. The expectation is that by 2050, 40 per cent of Baoding's GDP will come from the renewable energy sector. In the meantime, Baoding has become host to a number of major wind power equipment suppliers as well as R&D firms. A notable example is HuaYi Wind Power, which was jointly established by the Chinese Academy of Sciences (Institute of Engineering Thermophysics), the

Chinese Wind Energy Association and the Baoding National New Energy and Energy Equipment Industrial Base to promote and speed up the development of indigenous rotor blade technology.

Shenyang's Economic and Technological Development Zone, is home to General Electric Energy Co., A-Power, Shenyang Blower Works (which in late 2008 partnered with AMSC to develop a 2MW turbine due in 2010), China Creative Wind Energy, Shenyang Huachuan Wind Power Company, and, since January 2009, Fuhrländer. The Shenyang wind energy cluster benefits from its close proximity to the Wind Energy Research Institute of Shenyang University of Technology(SUT), a pioneer in Chinese domestic wind energy development (the Institute was the first, among other things, to build a purely indigenous 1MW and 1.5MW turbine).

The case of A-Power demonstrates the benefits of technology clusters for the rapid development of the Chinese wind energy industry. A-Power got started in the wind energy field in 2008, when it built a manufacturing base in the Shenyang Economic and Technological Development Zone with technology licensed from Fuhrländer. In early 2009, the company agreed to establish a joint venture with GE Drivetrain Technologies to produce wind turbine gearboxes in Shenyang. It also established strategic partnerships with Tsinghua University in Beijing and the China Academy of Sciences in Guangzhou, to develop and commercialize new technologies. In July 2009, A-Power entered into an agreement with Shenyang Huaren Wind Power Technology Development Co. for the acquisition of Huaren's proprietary technology to commercially produce and sell 1.5 MW-grade wind turbines. At the same time, it formed the Shenyang Power Group (SPG), an alliance that brought together a range of local wind-energy-related technology companies, ranging from power equipment makers to engineering service providers. "The alliance was created to integrate local resources and leverage the manufacturing, engineering and government initiatives in the Shenyang area so that SPG can pursue large-scale, international projects in the alternative energy sector."[20] In October 2009, A-Power announced it had won a contract to develop a 19.5 MW wind park in Shandong Province for Datang International Power Generation, one of China's top five State-owned power producers.[21] Later that month, SPG entered into a joint venture agreement with American firms to build a 600 MW wind farm in West Texas (fully financed by Chinese commercial banks), for which A-Power will supply 240 2.5 MW turbines (using GE's gearboxes) – marking "the first instance of a Chinese manufacturer exporting wind turbines to the United States market" (Rudolf, 2009).

D. Conclusion

China owes its recent rise as a major global wind energy power to the fortuitous interplay of several factors: government policies and financial support (motivated largely by energy security concerns and economic and environmental considerations); enterprise strategies in response to government regulations (particularly local content requirements), which promoted and accelerated the development of indigenous turbine manufacturers and component suppliers; and local efforts to attract new-technology firms, which led to the establishment of several technology clusters. In each of these areas, State support – financial and other – has been crucial.

Admittedly, the Chinese wind energy sector suffers from a number of problems and shortcomings, which are recognized by the authorities. Until recently, the emphasis was primarily on capacity rather than connectivity. As a result, in a number of cases capacity was installed but has remained unconnected to the main electricity distribution grid. In other cases, installed capacity has underperformed due to problems with equipment. However, recent policies, such as the August 2008 directives issued by the Ministry of Finance, suggest that there is a shift in emphasis from capacity to grid connectivity (and thus generation), which is likely to push China's domestic turbine manufacturers and components suppliers to improve the quality of their products. If the Chinese wind energy sector manages to resolve these issues, it will be in a position to make a significant contribution to China's efforts to meet its growing demand for energy while at the same time curbing its GHG emissions.

IV. Liberalizing Climate-friendly Goods and Technologies in the WTO: Product Coverage, Modalities, Challenges and the Way Forward

ZhongXiang Zhang
Senior Fellow, Research Program East-West Center, Honolulu, Hawaii

- Liberalization of climate-friendly technologies, goods and services would contribute not only to increasing the choices available for importing countries, but also to lowering the costs of those choices, thus making it easier to mitigate climate change. However, finding a viable negotiating strategy for the liberalization of these goods has proved difficult in the WTO.
- In fact, most developing countries are hesitant to liberalize bound tariffs on dual-use products due to concerns about the adverse impact of such broader liberalization on their established domestic industries and jobs and, in some cases, on their tariff revenues. However, isolating products of single environmental use is technically difficult and time-consuming.
- Negotiators could therefore focus on identifying a narrow choice of climate-friendly products that would be acceptable to a broader range of countries, such as energy efficiency, renewable energy equipment, and products, technologies and services used for small-scale CDM projects (e.g. micro-hydro projects, efficient cooking and efficient lighting).
- Options to pursue this agenda in the WTO include a sectoral agreement or a plurilateral agreement, in this area. Alternatively, EGs liberalization can be negotiated under regional or bilateral trade agreements.
- While positive, the results of tariff reduction or elimination would not be sufficient, to disseminate the use of climate-friendly goods and technologies in developing countries. High tariffs are only one of the factors that determine access to and affordability of climate-friendly goods and technologies
- Other factors which must be part of a broader EGs package include flexibility in terms of longer implementation periods and less than full reciprocity, optional participation for least developed countries as well as technical and financial assistance.
- The successful experience of the Montreal Protocol, in which effective technology transfer and financial mechanisms are widely believed to have played a decisive role, can inspire WTO negotiators.

A. Introduction

The Doha Round Agenda (paragraph 31(3)) mandates negotiating "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods (Egs) and services." This mandate offers a good opportunity for fast track liberalization of climate-friendly goods and services. Agreement on this paragraph should represent one immediate contribution the WTO can make in the fight against climate change (Lamy, 2008).

Climate-friendly technologies (or goods) refer to those the production or utilization of which reduce climate risks to a greater extent than alternative technologies for producing the same product (or alternative products that serve the same purpose). Climate-friendly technologies include those aimed at improving energy efficiency or increasing energy generation from new and renewable sources and goods. Liberalizing such technologies, goods and services would contribute not only to increasing the choices available for importing countries, but also to lowering the costs of those choices, thus enable those countries to either comply with existing and future GHG emission commitments or to limit the growth of GHG emissions. The resulting market expansion from trade liberalization will put a downward pressure on prices in home-country markets and increase competition between imported and domestic goods, thus further lowering compliance costs. By increasing the dissemination of climate-friendly goods and technologies at a lower cost, trade liberalization will make it less difficult to set stringent GHG emission targets beyond 2012.

This paper focuses on environmental goods (EGs), as that is the area in which negotiations within WTO have been more active to date. This by no means undermines the importance of environmental services in preserving the environment and mitigating climate change. Indeed, many services directly address climate change mitigation.

B. What products to liberalize and how?

1. Negative approach versus positive approach

To indentify which goods and services to ban or promote, a basic distinction can be drawn between negative and positive approaches. A negative approach would be to identify specific goods and services that countries should be required to ban for trading. The Montreal Protocol on Substances that Deplete the Ozone Layer, which was signed in 1987 and has since been amended and strengthened, has taken this approach. The Montreal Protocol uses trade measures as one enforcement mechanism among several policy instruments for achieving its aim of protecting the ozone layer. Parties to the treaty are required to ban trade with non-parties in ozone-depleting substances (ODS), such as chlorofluorocarbons (CFCs) in products containing them (e.g. refrigerators), and potentially in products made with but not containing CFCs, such as electronic components. This latter provision has not yet been implemented primarily because of problems of detection, and also because of the small volumes of CFCs involved. These trade measures have been extended gradually to all the categories of ozone-depleting substances covered by the Montreal Protocol (Brack, 1996; Zhang, 1998). Accompanied with finance and technology transfer mechanisms, this approach has been effective in phasing out ODS and contributing to the recovery of the ozone layer (Zhang, 2009a).

It is clear which products must be banned under the Montreal Protocol, but it is less straightforward to identify products that should be banned in relation to carbon abatement and climate change mitigation. Every product or technology causes environmental harm or affects the climate to some degree. A climate-friendly product or technology is just a concept of relative environmental performance. Such a product or technology tends to be sector- and country-specific, and is subject to change over time. For example, natural gas is less carbon-polluting than coal. Shifting to natural gas has been indentified as part of the solutions for climate change mitigation. This has been the main reason why Qatar, in its submission to WTO, has proposed liberalizing natural gas and natural-gas-related technologies as a way to reduce GHG emissions. But natural gas is more carbon-polluting than wind power that emits zero carbon emissions when operating. A coal-fired power plant is more carbon-polluting than one which uses natural gas, but if coupled with carbon capture and storage (CCS) technology, it is more climate-friendly than a natural-gas-fired power plant without CCS. Besides, a country's choice of fuels and technologies depends to a large extent on its resource endowments and their relative prices. The fact that countries like China and India use more coal is not because they prefer it, but because of their abundant supplies of coal and its relatively lower price compared with its more environmentally friendly substitutes. Thus, while some countries or regional agreements (e.g. North American Free Trade Agreement) may have a negative list on services or on investments in certain technologies which are restricted, it is most unlikely that countries will broadly agree on a list of goods that need to be banned. Moreover, arguably, for the purpose of meeting a climate change mitigation objective, any likely ban or restriction would tend to be on goods that emit high levels of GHGs. This will face resistance from countries that object to the use of trade restrictions based on process and production methods (PPMs), partly because it is difficult for customs officials to distinguish between high and low GHG-emitting products. In addition, there is uncertainty about WTO compatibility in distinguishing a product based on the way that product is produced, rather than on the final product's characteristics. There is also controversy over whether WTO jurisprudence has moved beyond the PPM concept (Zhang, 2004; Zhang and Assunção, 2004; Howse and Van Bork, 2006). Thus a negative approach will not work in a post-2012 climate regime.

By contrast, a positive approach, which seeks to identify certain goods and services for enhanced market access, holds some promise. Establishing a list of goods, technologies and services in which trade is encouraged has its on problems, but is easier than having a common list of goods, technologies and services that need to be banned.

2. List, project, integrated and request-offer approaches

The question then is which EGs and services need to be encouraged. Identifying them depends on their definition. Given their conceptual complexities and a lack of consensus on their definition, WTO members have persistently disagreed over how to identify which EGSs should be subject to trade liberalization.

Three approaches have been proposed in the WTO negotiations. The OECD advocates a list-based approach, whereby goods and services on an agreed list will gain enhanced market access through the elimination or reduction of bound tariffs and non-tariff barriers (NTBs) permanently and on a most-favored-nation (MFN) basis. Such lists have been produced by the OECD and by the Asia-Pacific Economic Cooperation (APEC) group. The two lists have 54 goods in common at the Harmonized Commodity Description and Coding System (HS) 6-digit level. However, 50 goods on the APEC list do not appear on the OECD list, while 68 goods on the OECD list do not appear on the APEC list. The main difference between the two lists is that only the OECD list contains minerals and chemicals for water/waste treatment, while the APEC list includes a relatively more extensive set of goods needed for environmental monitoring and assessment. The OECD list also contains a large number of environmentally preferable products (Steenblik, 2005). Taking the OECD or APEC lists of EGs as reference points, the so-called "Friends of Environmental Goods" group of countries, comprising Canada, the EU, Japan, the Republic of Korea, New Zealand, Norway, Switzerland, Taipei, Taiwan Province of China, and the United States proposed in April 2007 a list of 153 products. Just prior to the United Nations Climate Change Conference in Bali in December 2007, the EU and the United States submitted a joint proposal at the WTO calling for trade liberalization of 43 climate-friendly goods that were identified by the World Bank (2007) from a list of the Friends' 153 products, with the aim of securing a zero tariff for these climate-friendly goods by 2013.

Many developing countries have consistently expressed concerns about using a list of environmental goods slated for expedited liberalization, noting that a number of products on such a list are primarily of export interest to industrialized countries, thus compromising the development dimension.[22] And the Indian Ambassador was quoted as saying that this EU-United States proposal was "a disguised effort at getting market access through other means and does not satisfy the mandate for environment" (ICTSD, 2007a). Another sticking point is related to the issue of dual use, in that many product categories proposed on an EGs list include, at the HS 6-digit level, other products that have non-environmental uses in addition to environmental uses. In response, India has advocated a project-based approach, whereby each WTO member would designate a national authority to select environmental projects based upon criteria developed by the Special Session of the Committee on Trade and Environment and whose domestic implementation would be subject to WTO dispute settlement. The EGs and services required for a thus selected environmental project would temporarily enjoy preferred market access for the duration of the project. India has argued that the project approach would ensure that the approved EGSs are used for environmental purposes. Argentina has proposed an integrated approach that aims to bridge the gap between the list approach and project approach. It resembles the project approach but with multilaterally agreed pre-identified categories of goods used in the approved projects. Brazil has suggested a request-offer approach, whereby countries would request specific liberalization commitments from each other on products of interest to them and then extend tariff cuts deemed appropriate equally to all WTO members on an MFN basis. Brazil has argued that this approach follows along the lines of previous GATT/WTO negotiations and takes into account developing-country interests more adequately than the common list put forward by the EU-United States submission (ICTSD, 2007a, b). An analysis of the Friends' 153 EGs list by Jha (2008) indicates that a handful of developing countries are among the top 10 importers and exporters in various categories of EGs relevant to climate change mitigation. Based on these findings, she suggests that these countries could usefully engage in a request-offer approach to ensure trade gains. In this way, while the benefits of trade liberalization may be multilateralized, the cost would be borne by only a few players. These would be the very players that have a lot more to gain through liberalization.

All these different arguments clearly suggest that some WTO members have yet to be convinced of the climate mitigation credentials of some of the products that Europe and the United States have proposed. Moreover, advancing technologies will inevitably eclipse the continuing merits of some existing products. Thus an exclusive focus on the liberalization of these existing products raises the risk of being locked into current patterns of international trade in technologically advanced climate change mitigation products (i.e. producers of technology and importers of that technology). Furthermore, the developing world is in search of both an economic and an environmental gain through these negotiations under the Doha Round – and rightly so (Lamy, 2008). Even if these negotiations are on environmental issues, they must nevertheless deliver a trade gain if they are being conducted through the Doha Round of the WTO.

C. The way forward

There are significant export opportunities for developing countries in a large number of low-tech EGs in the core list of environmentally preferable products developed in a study by UNCTAD (2005b), and they also happen to be dual-use products (Hamwey, 2005). However, most developing countries are hesitant to liberalize bound tariffs on dual-use products due to concerns about the adverse impact of such broader liberalization on their established domestic industries and jobs and, in some cases, on their tariff revenues (ICTSD, 2008; World Bank, 2007). They insist in applying a single end-use parameter in screening EGs, and only those indentified EGs based on this parameter would then be taken up for tariff reduction negotiations (Howse and Van Bork, 2006). Isolating products of single environmental use requires assigning clearer HS codes or product descriptions for environmental goods. The HS allows countries to track trade volumes and tariff levels. The more digits there are in a code, the more specific is the description of the product. Given that HS numbers for products are currently harmonized across WTO members only up to the six-digit level, clearly identifying goods of single environmental use needs to go beyond this level. However, harmonizing the HS codes beyond the six-digit level will be time-consuming and would not be viable, given the short time horizon for a possible conclusion of the Doha Round and the timing of review cycles of the World Customs Organization (see the commentary by Vikhlyaev in this Review for a further discussion on dual-use and the limitations of the HS nomenclature).

What are the other options that need to be explored to accelerate liberalization of EGs? Arguably, countries are likely to agree upon a narrow choice of climate-friendly products that would be acceptable to a broader range of countries rather than a broader range of products that would be acceptable to only a few countries. One way forward along this line is to focus initially on specific EGs sectors in which the interests of both developed and developing countries coincide in fostering trade liberalization. Increasing energy efficiency is widely considered the most effective and lowest cost means of cutting GHG emissions, and trade in renewable energy equipment in developing countries appears sensitive to tariff reductions (Jha, 2008). Moreover, industrialized countries are set to take on higher proportions of renewable energies in their energy mix, either in order to comply with their GHG emission targets or with the aim of reducing their dependence on foreign oil, or both. Thus the initial round of liberalization should include renewable energy products and energy-efficient technologies. The World Bank (2007) estimates that the removal of tariffs for four basic clean energy technologies (clean coal, efficient lighting, solar and wind) in 18 large developing countries would result in a trade gain of up to 7 per cent. The trade gain could be boosted by as much as 13 per cent if non-tariff barriers on those technologies were also removed. These gains, which were calculated based on a static trade analysis, were considerably underestimated because they failed to take into account the dynamics of these EGs (i.e. trends in growth of their export levels and the size of their world export market). In addition to the trade gains, using these more climate-friendly technologies and products to replace those that are more GHG-polluting will translate into a significant reduction in GHG emissions. Therefore, clearly, liberalizing trade in low-carbon goods and technologies would serve both trade and climate mitigation interests.

A "procedural" area of accelerated liberalization relates to products, technologies and services used for small-scale CDM projects (e.g. micro-hydro projects, efficient cooking and efficient lighting) and programmatic CDM.[23] The CDM has been partially successful (Zhang, 2008): the global number of CDM projects registered and in the pipeline by August 2009 totalled 4,588 (UNEP Risoe Center, 2009) – well above what was envisioned by countries when they negotiated, designed and launched this mechanism. However, the lion's share of these CDM projects has gone to a handful of major developing countries like China and India, whereas many countries, especially those in sub-Saharan Africa, have been left out. One of the main reasons is that the transaction costs associated with the CDM project cycle have seriously hampered small-scale CDM projects in these countries. Although registration fees are set considerably lower for small-scale CDM projects, and simplified methodologies and procedures are also set for those projects, many other transaction costs are independent of project size and will thus have a bigger relative impact on small-scale CDM projects. Programmatic CDM, which bundles together small-scale CDM projects or a programme of activities, makes a better contribution to sustainable development and communality empowerment than a single CDM project, but it entails high transaction costs. Thus, liberalizing products, technologies and services in this area could reduce equipment costs and contribute to lowering transaction costs for potential investors. This would facilitate capitalizing on the untapped potential of programmatic CDM and extend the mechanism's reach in terms of both project type and geographical spread.[24]

Even in these two areas, developing-country concerns about the possible impacts of liberalization on their domestic industries would need to be addressed before a deal could be hammered out. This applies particularly to environmental goods and technologies that developing countries are not competitive in producing. Fox example, with regard to wind turbines, India has imposed very high tariffs with the aim of encouraging domestic production and jobs, and China has put in place a local content requirement (Alavi, 2007; Zhang, 2008). These policies act as barriers to foreign suppliers of wind turbines, and are seen as beneficial for local wind turbine makers. Indeed, the three largest local turbine makers in China – Sinovel Wind, Goldwind Science and Technology, and Dongfang Electric – account for an increasing share of total new installations in the country. Together they now supply over 50 per cent of a market once dominated by foreign firms until 2008. However, such policies hurt home countries in financial terms. While being less costly, domestic wind turbines in China break down more often and their overall capacity factors are several percentage points lower than those of foreign models. Such a few percentage points difference might not seem significant, but could well make a difference between a wind farm that is economically viable and one that is not (Zhang, 2009b). Thus while the local content requirement may be considered necessary when the domestic market is dominated by foreign firms, it becomes questionable when local turbine makers begin to dominate the market as is now the case in China. This clearly exemplifies challenges ahead and uncertainty about whether a deal can be concluded on a desired level of trade liberalization. Needless to say, the objective of having an agreement on EGs or a subset of EGs – such as climate-friendly goods – under WTO should be pursued as the best choice. However, should WTO members fail to reach such an agreement, then alternative options, ideally still under the Doha Round, need to be explored, although business groups have even suggested removing EGs from the Doha agenda.[25]

An agreement similar to the Information Technology Agreement (ITA) is one option to consider. However, it would require a certain number of members representing a minimum percentage of trade in climate-friendly goods and services to join[26] in order for it to come into effect (World Bank, 2007). Such an agreement would be open to voluntary participation, and once in effect, the benefits of trade liberalization in climate-friendly goods and technologies would extend to all WTO members on an MFN basis. The ITA has incorporated a mechanism for review of product coverage every three years. This may have tempered the disappointment of many countries with the initial exclusion of certain products. Given that developing countries are currently not significant suppliers of climate-friendly goods and technologies, priority should be given to additional products being submitted by developing countries for inclusion in a future review. However, the downside of this ITA mechanism is that no new products have ever been added since 1997. Thus developing countries may be suspicious of this offer for review, and feel reluctant to join.

Another option is a plurilateral agreement in this area, similar to the WTO Agreement on Government Procurement. WTO members could opt to sign up to such an agreement or not, but the benefits of trade liberalization would extend only to participating members on an MFN basis, unlike the aforementioned ITA-type Agreement which would extend MFN treatment to non-signatory WTO members as well. While such a plurilateral agreement would not be ideal, it would still have value, particularly if the key trading parties were involved. Such an agreement could eventually be made multilateral once a certain number of members representing a minimum percentage of trade in climate-friendly goods and services joined.

Other options for this sort of agreement may be within the context of regional or bilateral trade agreements. Such agreements aim to liberalize substantially all goods at the HS six-digit level. As a result, product classification and the dual-use problems associated with WTO negotiations on EGs and services may be less of a concern. These agreements would liberalize EGs fully. However, the downside of the regional or bilateral trade agreement approach is that trade may be diverted from countries that are most efficient at producing certain EGs but are excluded from those agreements. Moreover, by entailing generally the zero rating of all products, this approach would remove any tariff differential between EGs and their non-preferable like products. Whether such an elimination of tariffs in EGs would be enough to encourage their larger utilization in a competitive environment with other non-EGs would depend on their relative prices and the stringency of environmental policy in the home countries. Even if the prices of energy-efficient EGs were higher than those of their non-preferable like products, this would not necessarily put those EGs at a disadvantage. Provided energy subsidies are removed and costs are attached to emissions reductions, any higher initial costs of energy-efficient EGs may well be compensated by cost savings through energy savings over their lifetimes. The demonstration of new EGs (technologies) that a country is not yet familiar with but has a high potential to replicate plays a role in this context as well: it is the first but crucial step in showing the effectiveness of these new EGs in cutting pollution and supporting its spin-off to the rest of the economy.

This paper focuses on liberalizing climate-friendly goods and technologies through the reduction or elimination of tariffs. Undoubtedly, the results of such a tariff reduction or elimination would be positive, but would not be significant for increased uptake of these goods and technologies in developing countries. Many African countries already have very low tariffs on many environmental goods, but import few, if any, of them because of a lack of purchasing power and technical assistance. Also, as tariffs in developed countries are already very low – generally less than 3 per cent for EGs on the OECD list (Vikhylaev, 2003) – and as not all EGs are sensitive to tariff reductions,[27] the access of developing countries to developed-country markets would depend more on reduction or removal of trade restrictions in terms of NTBs, such as technical standards and certification requirements, labelling requirements, and tied-aid that grants tariff preference for a donor country's goods and services, as well as tax and subsidy measures. All these NTBs are considered significant impediments to developing countries' access to developed-country markets. Developing countries constantly refer to intellectual property rights as a barrier to access much-needed and advanced low-carbon technologies, in addition to their high licensing fees or royalty payments. All this suggests that high tariffs are only one of the factors that determine access to and affordability of climate-friendly goods and technologies, and thus that action beyond tariff reduction or elimination is also needed.

Therefore to serve the best interests of developing countries and enable them to access both climate-friendly goods and technologies at an affordable price and developed-country markets, there is a need to consider other efforts rather than adopting an exclusive focus on tariff reductions or elimination. Special and different treatment provisions will also be essential to take into account the concerns of developing countries. These include less than full reciprocity and flexibility in terms of longer implementation periods – or both – for developing countries, and optional participation for least developed countries. In addition, a package of technical and finance assistance is badly needed to ensure that all developing countries are able to benefit from the rapidly growing world market for climate-friendly goods and technologies. At least one WTO developed-country member – Canada – in its submission has recognized the importance of such assistance and has pledged to provide it. All these aforementioned initiatives could be made part of the EGs package for it to work. Moreover, WTO EG and services talks need a boost from other areas. Effective technology transfer and financial mechanisms are widely believed to have played a decisive role in making the Montreal Protocol work effectively (Zhang, 2009a). Given that the scope of economic activities affected by a climate regime is several orders of magnitude larger than those covered by that Protocol, technology transfer and deployment, financing and capacity-building are considered to be even more essential components of any post-2012 climate change agreement that developing countries would agree upon to succeed the Kyoto Protocol. If and when such a post-2012 climate change deal is reached, it would significantly enhance the possibilities of a breakthrough in reaching an EGs and services deal under the WTO.

V. WTO Negotiations on Environmental Goods and Services: the Case of Renewables

Alexey Vikhlyaev
UNCTAD Secretariat

- The momentum created by the move towards a new international climate agreement is bound to influence the modalities for international cooperation, including in the WTO, be it as a separate WTO climate initiative or in the context of the Doha Round negotiations. In fact, climate friendly goods in general, and renewables in particular, have emerged as the strongest candidates for "outcome testing" in the negotiations on environmental goods.
- How important is the role of trade and trade policy with respect to these goods? What is the level of the competitive relationship between developed and developing countries? How is it possible to ensure that the environment and, in broader terms, sustainable development, becomes the most important part of the complex scale by which success in the negotiations will be measured? Finally, are there enough markets – or are these markets strong enough – to cause concern by WTO members about access to them?
- The search for the answers would benefit tremendously from the real-life economics as well as a horizontal analysis of existing WTO agreements from the trade and environment perspective. Clearly, linking trade and climate change is impossible without linking trade and energy. The link involves competition and investment issues, and the WTO rules are still in the making in these areas. And whether we are talking about the environment, energy or climate change, it is "markets" and "market creation" rather than "trade" and "market access" that inform the core of policy concerns in these areas."

A. Introduction

The momentum created by the move towards a new international climate agreement is bound to influence the modalities for international cooperation, including in the World Trade Organization (WTO), be it as a separate WTO climate initiative or in the context of the Doha Round negotiations. A first sign of that is the focus on the interface between energy and environmental goods and services. Indeed, energy – its production, transmission and use – is arguably responsible for as much as half of the world's environmental problems.

Since the trade ministers' dialogue in Bali in December 2007, a new policy discourse has developed which favours the idea of including renewables[28] and technologies for cleaner utilization of conventional energy within the scope of the negotiations on environmental goods and services. Arguably, other climate-friendly goods, such as energy-efficient construction materials and appliances, or even goods derived from more GHG-efficient processes and production methods, would also be considered.[29] Whether the negotiating proposals that have followed suit are essentially a political move or are here to stay is subject to debate.

Should the negotiators choose to focus on climate friendly goods and services as a matter of priority, they will have to seek a better alignment between the mission and means. WTO Director-General Lamy suggested that the WTO Members could work along two simultaneous tracks. One track is for technical discussions in the negotiating groups. The other is for "outcome testing" through bilateral or plurilateral discussions as Members seek to clarify the deal, its value and the scope for flexibilities.[30]

On a technical level, there are open questions relating to product coverage and negotiating modalities. Is there a scope for a sectoral agreement on tariff reduction or elimination? Are there alternatives, considering climate friendly goods are, by definition, environmentally preferable products (EPPs)? Can they be redefined as a class of their own based on the source of energy, i.e. the resource rather than their use? And would it not make more sense to refocus the negotiations on non-tariff barriers to trade?

On a higher plane, "outcome testing" could shed light on some important – and somewhat counterintuitive – questions. Does a straightforward approach to the liberalization of trade in climate-friendly goods and services square with the real life economics? How important is the role of trade and trade policy? What is the level of the competitive relationship between developed and developing countries in the environmental area? How is it possible to ensure that the environment and, in broader terms, sustainable development, becomes the most important part of the complex scale by which success in the negotiations will be measured? Finally, are there enough markets – or are these markets strong enough – to cause concern by WTO members about access to them?

B. Should renewables be fast-tracked?

Renewables can certainly present the negotiators with a telling case study of the substantive links – or the absence thereof – between the mandate provided for in paragraph 31(iii) of the Doha Ministerial Declaration and the negotiations. However, can they also serve as a litmus test for the various approaches to the liberalization of trade in environmental goods and services? After all, renewables are a special case.

The value of trade in renewables is still relatively low. Much of that trade is internal to a few multinationals. Developed countries dominate the high-technology end of exports (although China is rapidly moving into the high-tech segment, as can be seen from the commentary of Dong Wu in this Review). On the low-tech side and in biofuels, developing countries are significant exporters, but only as a group (UNCTAD, 2005a).

Trade in individual parts and assembled components is several times bigger than that in complete systems. For example, in modern wind technology assembled turbines are produced mainly by Denmark, Japan, Spain, the United States and more recently China, but the turbines consist of a number of components that are produced by a much larger number of countries (e.g. gear boxes of the kind used in wind turbines are currently manufactured in and exported from more than 80 countries).[31]

There is considerable disparity in tariffs on renewables – from 0 to 40 per cent, and in some cases even 100 per cent – but it is the tariffs in the 20–30 per cent range that seem to restrict most trade. However, some relatively high tariffs on finished goods are found in those few developing countries that may actually need those tariffs to protect their developing industries and where the scope for other support measures is limited. For instance, the duties may be set at 3 per cent for individual parts, at 8 per cent for assembled components, and at 17 per cent for entire pre-assembled turbines. Biofuels are a case apart, since tariffs depend on whether biofuels are regarded as an agricultural product, and therefore subject to higher rates under the current WTO Agreement on Agriculture, or as an industrial product, with relatively low tariffs. For instance, the current EU tariffs on biodiesel are around 6.5 per cent, while tariffs on ethanol range between 40 and 100 per cent, depending on the price.[32]

Some experts argue that lowering or even eliminating tariffs only on finished renewables would choke off new opportunities for their production and exports by developing countries (UNCTAD 2005a). Hypothetically, it may even lead to negative protection, with tariffs for complete systems being lower than those applied to individual parts and assembled components.

This argument would favour a more sophisticated approach to trade liberalization based on the chain of manufacturing; breaking down the various categories of renewables into specific parts and components and identifying which countries have – or can develop – the capacity to supply them.[33] However, such an approach would significantly aggravate the problem of dual use. Moreover, it is not clear whether that approach would be technically feasible and politically acceptable.

The markets for renewables are extremely distorted by subsidies and preferential procurement policies of governments in developed countries, and by tied aid and multilateral projects that carry tariff waivers and offer long-term concessions (up to 25 years), as well as by local content requirements in developing countries (local content requirements are used by some developed countries as well.) In addition, winning bids may be fast-tracked through the approval procedures to develop project sites, with guaranteed grid interconnection, financial support for grid extension and access roads, and preferential loans and tax treatment. These measures are much more important than tariffs, including from the market access perspective.

How important are tariff considerations with respect to renewables? So far, special incentives for market creation[34] have played a major role because conventional energy policies do not fully value energy security, economic development and environmental benefits – the so-called 3Es. As a result, renewable energy technologies, particularly the most dynamic, second-generation ones such as those based on wind, solar and new bio-energy, tend to be concentrated in only a few countries. For instance, 85 per cent of the world's total wind energy is produced by five countries: Denmark, Germany, India, Spain and the United States, and 86 per cent of PV systems by three countries: Germany, Japan and the United States. This is a challenge and a barrier (OECD and IEA, 2004).

In order to analyse the likely path for renewable energy development, it is not sufficient to conduct technical studies providing a breakdown of wind, PV, geothermal and biomass steam generating technologies into their major components, and identify those components by HS codes.[35] It requires a more detailed picture, building on an analysis of locational factors such as market size (to the extent that the census of manufacturing activity permits), efficient radius of shipping, technical capacity and local customization. The analysis would have to consider the energy and regulatory sectors of each country, looking at market size, current power generation profiles, regulatory policies, the use of renewables and other variables. In the absence of such an analysis, it is not entirely clear how the negotiating proposals currently on the table in the WTO would balance the market opportunities offered by climate-friendly technologies with access to those technologies by developing countries.

Clearly, the development of renewable energy could take place along two quite different paths. One path would see the bulk of demand for renewables met by finished products exported from a handful of developed countries to developing-country markets. The other path would see an increasing allocation of at least a portion of the component manufacturing to developing-country industries, with those components then used in the final assembly of the renewable generation technology. Either of the paths could supply the necessary energy generation, but their development effects would be quite different.

In principle, developing countries have two very substantial assets that favour their competitiveness in renewables: (i) abundant renewable resources, and (ii) in many cases, lower costs of production of equipment, components and biofuels. Taken together these factors point to considerable scope for trade and cooperation, particularly since more mature renewable energy technologies (e.g. hydropower, geothermal and biomass combustion) are close to reaching saturation in developed countries.

However, there are a number of factors that complicate developing countries' participation in renewable energy markets. These include their up-front investment needs, very limited availability of long-term loans (i.e. loans of more than seven years), limited cross-border financing opportunities (e.g. because of loss of tax incentives, unproven technologies for local needs, such as available equipment being too large or too sophisticated), gaps in infrastructure, such as lack of a grid network, complexity and uncertainty of the regulatory environment, especially for small projects, and of due diligence and monitoring requirements, and drawbacks in the tendering process, all of which may create non-tariff barriers to trade.[36]

While the main drivers for renewable energy in developed countries lie in environmental protection becoming an increasingly important public policy objective, particularly the role that renewable energy can play in meeting GHG reduction targets, in developing countries it is the shortage of energy that is the main factor.

In any case, it seems clear that the liberalization of trade in renewables, to be commercially meaningful and financially viable, should lead to – or be accompanied by – market-creation measures, expanding the number of countries that are shouldering deployment policies, and enhancing international cooperation. Financial flows and official development assistance targeting climate-friendly technologies can play a catalytic role in the uptake of renewables in developing countries through increased trade, investment and technology transfer. In this regard, it is worth noting the G-8 financial ministers' initiative to set up climate investment funds with a view to assisting the efforts of developing countries (G-8, 2008). Furthermore, the World Bank is working to deepen the reach of those funds in cooperation with the regional development banks in Asia, Africa and the Americas. Innovative financing in dealing with climate change is needed now, more than ever, to confront what has emerged as the major threat to the development priorities of the poorest countries and communities.

C. Listing of environmental goods: what could be a logical outcome?

The negotiating proposals based on the idea of listing environmental goods draw from the APEC Early Voluntary Sectoral Liberalization, which, in turn, was an attempt to replicate the Information Technology Agreement (ITA) for other sectors, including the environment. The ITA is a rather successful example of negotiations based on *critical mass* in a sector where advanced economies saw themselves as net exporters. Other examples are basic telecommunications and financial services.

The sectoral negotiations contemplated by some delegations in the current negotiations on non-agricultural market access that are based on a critical mass criterion may be a problem in itself: there are members opposed to the idea of sectoral agreements in general, and with respect to climate-friendly goods in particular.

Besides, the agreements from the "build-in agenda" period were not so much about *critical mass* as about going with the flow of markets, commercial logic and technological change. All the three agreements - telecoms, ITA and financial services - were concluded in exceptional circumstances: structural changes in the telecoms sector, the Asian financial crisis, the pervasive nature of information technology and the need to do away with taxing own inputs. Does climate change provide similarly compelling reasons?

Were it not for the pervasive problem of dual use concerning most environmental goods, the very idea of achieving reciprocity in this particular negotiation would seem an aberration. Even a cursory look at the interface between the environmental and energy industries reveals a basic asymmetry: while the developed countries are looking for winning propositions in terms of market access, for developing countries, it is market creation that is more important. Logically, this means that environmental benefits should mainly go to one set of countries and trade gains to another. Reciprocity defies this logic.

Besides obscuring the real-life economics underlying the negotiations, dual use creates intractable technical problems. While the HS can capture most renewables, the ubiquitous nature of some goods and their component parts means that the dual use problem will remain over and above what could be sorted out by introducing greater specificity in the HS tariff codes. As for GHG-efficient goods or goods produced in a GHG-efficient way, there are simply no HS codes to match. Moreover, climate or energy efficiency include fast evolving technologies, hence the identification of such goods in a closed list is a moving target. The inclusion of goods derived from GHG-efficient process and production methods (PPMs) is especially problematic as it may dramatically increase the scope for protectionist measures.

The two types of renewable energy equipment that can pass the single use test at the HS 6-digit level are: (1) hydraulic turbines (8410.11, 8410.12, 8410.13)[37] and (2) wind powered electricity generating sets (8502.31). Ethanol (2207.10) and methanol (2905.11) fail the single use test as these are common chemicals in many synthetic hydrocarbon reactions, in addition to being "green fuels". Biodiesel is exclusively used for transportation or energy production but is an *ex-out* [38](3824.90 ex) as it is categorized under the large subheading of "products, preparations and residual products of the chemical or allied industries". Solar cells also form part of a large subheading (8541.40), which includes semiconductor devices and light-emitting diodes.

The problem with dual use may arise either because the HS is not specific enough to capture "environmental goods", or because dual use is inherent to these goods. Creating *ex-outs* in national nomenclature may serve to address the former problem, but not the latter. Experts tend to agree that for the vast majority of renewables, dual use is a function of their ubiquitous nature, whereby they can be employed for uses other than environmental. Therefore, using ex-outs to "drill down" to single use from dual use does not seem a viable option (OECD, 2006).

Experience with the ITA – and this Agreement is often cited as a possible model for a "list-based" approach to negotiations on environmental goods – has revealed the problem of ensuring a consistent interpretation of customs classifications. This problem has led to disagreements among trade negotiators as well as between customs authorities and traders, to the point that some analysts are questioning the relevance of the Agreement and the technological assumptions it was based on.[39] If there is an overall lesson to be drawn from the ITA and other sectoral agreements, it is that ex-outs have been – and should remain – the exception rather than the rule.

The recent legal challenge to the application of the ITA Agreement reveals the drawbacks of the Agreement. A positive list, based on precise nomenclature, proves self-limiting and does little to solve the structural problem of dual use. The all but inoperable review mechanism has largely failed to manage the product coverage.

Will litigation help develop a case law regarding the tariff classification issues for dual use products? We do not know, but the ruling may serve as a basis for renegotiating the ITA in such a way that it becomes more accommodating of technological change. In the meantime, analysts converge on the following conclusions. To be manageable, the product list should be negative, i.e. only exceptions should be listed. There should be disciplines on handling dual use products at customs, especially those products that embody technological change.

Since the existing definitions of climate positive goods are as much about the resources as they are about the environment, the negotiators could, in principle, consider a particular category of *environmentally preferable products* (EPPs) as "single source" or "single process", from an environmental impact perspective. For instance, there could be agreement that renewables constitute EPPs based on the *source* of energy (i.e. the *resource*) rather than on the *use* of the products, as their categorization is not so much based on the specific category of technologies (e.g. electricity-generating motors, power converters or inverters) as it is on the *source* of the power (e.g. biofuels, low-head hydro, solar, wind or geothermal). Other goods using a particular source of energy could be classified as a single source within a category (e.g. electric cars or trains which fall under HS 8703 or HS 8601).

Certain climate-friendly goods can be differentiated easily on the basis of their physical characteristics alone. However, the majority of these goods owe their environmental performance to a combination of features, and can only be definitively identified through testing. In such cases, standards and (third-party) certification or labels are the only mechanisms of product differentiation. Energy and fuel efficiency standards are particularly relevant in this context.

Given the special interest in climate-friendly goods, difficulties in capturing some of these in the HS and the generally low tariffs that have prevailed with respect to these products, it might prove easier and more productive to focus the negotiations largely on non-tariff barriers (NTBs) (UNCTAD, 2004). Indeed, unless WTO members address the NTBs affecting trade in these goods, all the noble discourse and environmental claims with respect to these products will remain empty gestures.

However, there is a contradiction in attempting negotiations on NTBs and at the same time slamming the door on PPMs, particularly since PPMs pose a problem for the negotiators only if there are no other means of product differentiation. Besides, PPM-free does not necessarily mean problem-free. Some (climate-friendly) goods may still be problematic since they require agreement on a relative standard (i.e. the products in question must be better than some baseline). The judgment of a standard is itself difficult; for instance, is a fuel-efficient car a green good? How efficient must it be? Moreover, technology evolves, and today's "green goods" become tomorrow's baseline.

D. How to negotiate non-tariff concessions

Interestingly, it is the sectoral approach that has been instrumental in promoting a comprehensive treatment of all factors affecting trade, including NTBs. In fact, negotiations encompassing both tariffs *and* NTBs constituted the original meaning of the term *sectoral approach*, the meaning that prevailed for a relatively long time.

The various sectoral initiatives have gradually raised the level of ambition with respect to NTBs, often making them the necessary parameters of a well-balanced negotiated package. However, these NTBs usually had nothing to do with the sectors in question! More often than not, sectoral negotiations had been tried for several sectors in parallel, and it is cross-sectoral demands and linkages that contributed towards a balanced overall outcome.

Again, the ITA provides a striking example. Contrary to a common view, the ITA is not a "stand-alone" deal; rather it is a number of product groups repackaged under an appealing name. The negotiating history is very telling. Early on, some participants took the position that, because the results of an ITA would not benefit all participating countries evenly, "balancing measures" would be needed outside the IT sector. At one point, trade ministers exchanged lists of sectors where they would like to expand the IT package of commitments. The various proposals aimed at broadening the package prompted a comment about the ITA being a short-hand for "Information, Textiles and Alcohol" agreement.[40]

Could NTBs be used as a balancing tool in addressing this asymmetry in the negotiations on environmental goods in general, and climate-friendly goods in particular? This seems unlikely, as environmental goods do not exhibit any specificity as far as NTBs are concerned, which is not surprising since they are essentially industrial goods used for a variety of purposes.

On the other hand, negotiating NTBs raises some serious concerns. First, there is an apparent link between product exclusion and NTBs, i.e. sensitive products are the ones for which NTBs are particularly important. Second, the greater complexity of negotiations on environmental goods invariably raises questions about the usefulness – and the administrative costs – of addressing NTBs in this context. Third, there may simply not be enough time to equip the negotiators with the necessary data and tools. This is of course assuming that the Doha Round does not collapse. One of the reasons for the ITA's success was the determination of some parties to postpone NTB negotiations to a second phase of the ITA.

For instance, several issues arise in the context of the Agreement on Technical Barriers to Trade (TBT Agreement). Certain technical regulations that create obstacles to trade in renewable energy or renewable technologies are necessary on legitimate environmental grounds (e.g. risks to wildlife). Other regulations may be designed, intentionally or inadvertently, to be based on the traditional predominance of fossil fuels or nuclear generation. A number of questions await their authoritative interpretation. For instance, to what extent do regulatory regimes recognize metals as being distinct from synthetic chemicals? Can biofuels or substances that compose biofuels (e.g. secondary biomass) receive regulatory treatment based upon assumptions that they are being traded as waste or for purposes other than the production of renewable energy and which may make the substances more hazardous? How justified are technical regulations that limit the use of ethanol blends? Answers to these questions will determine the extent of the regulatory burden on photovoltaic manufacturers and biomass companies.

Subsidies for oil, coal, gas and nuclear power are often cited as a very significant barrier to renewable energy. On the other hand, breaking out of this pattern of just a handful of countries participating in renewable energy deployment would necessitate a shift away from subsidies and preferential public procurement in the renewable energy sector itself. It is important to examine whether and to what extent trade regulations could be used to challenge or discipline policies (regulatory barriers) that disadvantage renewables. A reverse question – whether and to what extent government policies to promote renewables may be disciplined as non-tariff measures – is equally valid. With some foresight, one can see the "subsidization" angle in the international trade in carbon emission permits and carbon offset arrangements.

A large number of countries have implemented special requirements or labelling schemes for energy and fuel efficiency. Can one assume that the differential regulatory or tax treatment of products based on energy and fuel efficiency would be permissible under the WTO rules?

The main criterion of *likeness* since the *EC-Asbestos* [41]case is the competitive relationship between products. Arguably, in some (developed) markets, and to the extent that energy or fuel efficiency affects their competitiveness, the products in question – one efficient the other not - could be considered *unlike* in the sense of GATT Article III. After all, such differences normally depend on the design and therefore translate into physical characteristics. More importantly, consumers in these markets may have compelling reasons, environmental or economic, to prefer energy or fuel efficient goods.

However, even if considered *like* because they do compete in the same market, there is still Article XX, which can serve to justify different regulatory or tax treatment on the basis of (a) the importance of the value proposition - environment or sustainable development in this particular case - and (b) whether or not the regulation or tax in question is apt to contribute materially to the government's objective.

In most cases though, energy or fuel efficiency requirements will be put in the language of technical regulations and therefore come under the TBT Agreement, which, in a way, merges Article III and Article XX and stipulates that technical regulations serve a legitimate government objective and be not restrictive on trade more than necessary.

Taking recourse to Article XX or to the TBT Agreement is bound to lead to the same results, although in different ways. Regulations and labelling programmes to do with energy efficiency and based on (few) international standards set by the International Electrotechnical Commission or the ones that follow closely the guidelines, methodologies and best practices developed by expert bodies such as the US-led Collaborative Labelling and Appliance Standards Programme (CLASP), and the APEC Energy Standards Information System (ESIS) are less likely to be challenged as unnecessary obstacles to trade within the meaning of the TBT Agreement. The situation with fuel efficiency is less certain as there are no international standards.

With respect to biofuels, it is not clear, how the Agreement on Agriculture may affect fuel farming and bioenergy in general. Under the current regime, there is a structural bias against some important biofuel products. SPS measures mainly affect feedstock due to their biological origin. Where the product's end-use cannot be determined at the border, strict regulations on residues are applied equally to crops destined for animal or human consumption and to biomass feedstock. Sustainability standards and regulations are increasingly important to trade in biofuels.

The question is, whether the negotiators would be willing to take on the task of addressing these and other related issues in order to take better account of the specificities of trade in climate-friendly goods? And how far would they be prepared to go?

E. Living agreement instead of a living list?

If the case of climate friendly goods in general, and *renewables* in particular, proves anything, it is that a search for the meaning of environmental goods is a poor substitute for clarifying the meaning of trade in environmental goods, which is much broader than the General Agreement on Tariffs and Trade (GATT), and extends to cover at least some aspects of the movement of capital, services and technology, as well as people. One-dimensional obligations, with concessions limited to one type of transaction (i.e. cross-border imports) and one trade policy instrument (i.e. tariffs), may not be of much use to WTO members that lack much negotiating leverage to solve access problems caused by regulation or subsidization in major markets.

The alternative negotiating proposals exhibit an almost intuitive grasp of these issues. Take, for instance, the project-based approach by India, with its emphasis on the delivery of environmental services and technology transfer, or the joint Argentina-India approach, which is about companies: importers and service providers. The proposals essentially argue for opening up tariff rate quotas either under Article XX or under the Agreement on Government Procurement. They also suggest a different kind of coordination system for the negotiations, perhaps even a multidimensional agreement, with a view to finding a reasonable balance between environmentally meaningful commitments and their broad application across member States.

While the legal analysis of the negotiating alternatives may be fraught with uncertainties, WTO members are free to negotiate a new agreement, irrespective of existing WTO law, in order to accommodate any approach they deem fit and thus bypass the systemic problems that may seem insurmountable based on the status quo. Such an agreement would form part of the WTO system, on a par with other agreements, and will prevail as *lex specialis* over more general provisions.

Forging a framework agreement would require elevating the negotiations to the political level with a view to outcome testing, endorsing an overall approach to negotiating climate-friendly goods and services on a priority basis and securing coordination with other negotiating groups. Once the agreement is in place, WTO members could go back to more technical negotiations within the WTO Committee on Trade and Environment Special Session (CTESS) and other relevant groups to see the Agreement through in the respective fields of the WTO law. The proposal for a framework agreement was argued by Cottier early on in the negotiations. More recently, it was developed in a series of studies undertaken for UNCTAD (Cottier, 2006a; and Cottier and Baracol-Pinhao, 2008).

This is how Cottier and Baracol-Pinhao (2009) envisage the scenario with respect to climate-friendly goods and services. In the first instance, members would have to do some scoping. They may opt to implement the entire range of activities and sectors under the Kyoto Protocol, including electricity generation, transport and industrial processes, or they may agree on a particular sector to be taken as an initial target, e.g. electricity generation.

The negotiations on energy services in the current Doha Round may present an opportunity for ensuring that the commitments made reduce barriers to renewable energy. For instance, renewable energy obligations for electricity imposed on grid operators and retailers constitute commitments under the General Agreement on Trade in Services (GATS), and may be specified in their schedules accordingly.[42]

A potential overlap with certain aspects of GATS negotiations on energy services is not without problems, in particular with respect to the scheduling of commitments. Traditionally, the industry has not distinguished between energy-related goods and services. The current classification does not cover new services, which have arisen owing to structural changes in energy markets since 1991 when the services list was drawn up - the emergence of new technologies, concerns about energy efficiency or environmental protection.[43]

In the Doha Round, the request-and-offer process for energy services is based on the concepts of technological neutrality and neutrality of energy source.[44] However, members always have the possibility of makings commitments based on the type of energy they prefer. In other words, an energy-neutral classification can always be made energy-based in a schedule of commitments of a member.

A check-list may be required to deal with so-called energy related services that can be used for other purposes, too. For instance, Tier One in the EU–United States proposal covers energy-related services (e.g. engineering and maintenance services to optimize the environmental performance of energy facilities), and services for the design and construction of energy-efficient buildings and facilities. Tier Two covers a broad set of environmental and climate-related services, including energy, construction, architectural, engineering and integrated engineering services.[45]

Once the picture on the services front is sufficiently clear, the negotiators would proceed to identify the *goods* essential to the delivery of the selected environmental and energy services and negotiate tariff concessions using the proposed modalities and taking into account national priorities and programmes.

As far as NTBs are concerned, those most commonly discussed are *subsidies* and *standards for energy* and *fuel efficiency*. The introduction of sustainability standards and regulations may prove important to trade in biofuels.

Two options exist with respect to subsidies. Assuming subsidies to renewables are legitimate (in order to level the playing field with subsidized conventional fuel), an obvious choice is the revival of Article 8.3, known as non-actionable subsidies. A set of green box renewable energy subsidies may be identified and Members may agree, on a consensus basis, to refrain from challenging these because of their positive environmental effects. Some experts point out that the expired category of non-actionable subsidies falls short of fully achieving its goals since it is both over-inclusive - in the case of R&D subsidies to producing firms - and under-inclusive - for instance in the case of subsidies targeting energy efficiency. Alternatively, a provision modelled after GATT Article XX and complete with a necessity test similar to GATT Article X (b) could be introduced in the Agreement on Subsidies and Countervailing Measures (ASCM).

An even more obvious - but considerably more challenging - option is to use the ASCM to pursue climate protection objectives by effectively discouraging fossil fuel subsidies, which may take a variety of forms. Taking the cue from the negotiations on fisheries subsidies, one can envisage negotiations within the WTO with a view to Members agreeing to cap and reduce subsidies in the energy sector that are questionable on environmental grounds. Arguably, such negotiations could be linked to the fulfillment of commitments under international environmental regimes such as climate change (Howse, 2008, 2009)

There are possible approaches to dealing with regulatory barriers. An agreement on climate friendly goods may include pilot projects, as did the ITA II. Members might also consider a "smorgasbord" approach, along the lines of the current trend in the ISO towards declaring specific national, or regional or international standards as equivalent rather than having one standard as the only option. Such an approach could serve as a relatively efficient way for this negotiation to reduce transaction costs and distortions arising from multiple standards and technical regulations in major global markets.

The labelling of sustainable biofuels offers a possibility to rebalance, to an extent, the export interests and environmental sustainability objectives in the developing countries concerned. It can be pursued through specific provisions in the framework agreement. The agreement may also help coordinate the negotiations in NAMA with the negotiations on agriculture in dealing with the structural bias against some important biofuel products.

The Agreement might just be able to equip the negotiators with some means to address issues arising at the intersection of trade and the transfer of climate positive technologies. The most promising avenue, it would seem, is exploring the negotiating approaches enshrined in GATS, which affords Members a degree of flexibility to pursue transfer of technology policies. Thus, Members may design their GATS commitments in a way that facilitates technology transfer by specifying limitations and conditions in their schedules with a view to supporting such policies. They may also choose to liberalize types of services and define a sectoral coverage in such a way as to maximize the potential for technology diffusion.

F. Conclusions: market access or market creation?

There is an implicit contradiction between the tendency to include new issues and attempts to keep the negotiations within the remit of the GATT, and therefore restricted to tariffs on goods and market access.[46] What is the point of having opportunities if there are no capabilities? Even full market access does not mean climate-friendly goods will suddenly flow into countries in dire need of them. In fact, turning these needs into effective demand remains the main objective. And in the pursuit of this objective, market creation should take precedence over market access.

Of course, the WTO is not a development agency; its essential role is to regulate conditions of competition between domestic and imported goods. Thus the concept of competitiveness should be key to determining a negotiated outcome – as it is when determining likeness in evaluating environment-related trade actions. Right or wrong, all the negotiating approaches on the table make sense only when they concern goods that are a priori competitive. Where a competitive relationship exists, a negotiated outcome should ensure that competitive opportunities for the members are reasonably equal. Where a competitive relationship does not exist, or does not yet exist, WTO negotiations or disciplines are not, or not yet, commercially necessary.

In another study, not related to environmental goods, Cottier argues in favour of the idea of progressive regulation - as opposed to progressive liberalization (Cottier, 2006b). The idea finds explicit recognition in Article 27:5 of the Agreement on Subsidies and Countervailing Duties, which relates the phasing in of disciplines to export competitiveness in specific sectors and products. Importantly, it concerns products and not countries.

Environmental – or energy – subsidies are good examples. Given that the capacity to subsidize depends on the level of economic development, strict disciplines are necessary for developed countries or sectors, while more lenient standards could apply to countries and sectors at lower levels of development. The classical approach of differentiated transition periods is always an option.

Indeed, why take on new commitments or adopt additional rules or forge a new agreement if there is little or no competition? Would it not make more sense to wait until the environmental industries in developing-country members of WTO become competitive and graduate into a different regulatory league? And even then, should the scope for commercially significant free riding be limited, do the future disciplines necessarily have to include a market-access dimension?

The traditional approach to market creation in the WTO is through special and differential (S&D) treatment. However, this approach has largely failed, and a more effective set of measures is in order. Such measures may be developed by promoting the concept of issue linkage, i.e. coherence and multilateral cooperation in several dimensions and agreement over multiple issues, or an issues tie-in, i.e. the requirement that a particular agreement must span multiple dimensions of interaction, thus ruling out a single-issue agreement (Conconi and Perroni, 2002).

An issue tie-in is a stronger option, which could be pursued on two levels: (i) as an "extended coherence" in the relationship between the WTO and other international instruments (e.g. multilateral environmental agreements (MEAs), where part of an agreement becomes an *acquis* of another agreement); and (ii) within the WTO treaty itself, in terms of interfacing issues that are usually dealt with separately. In the former case, members States could pursue the objectives of the Kyoto Protocol within a framework agreement on environmental goods and services, and vice-versa, whereby the framework requirements of the WTO could be taken into account in negotiations under the Kyoto Protocol. In particular, members collectively could undertake to provide the necessary technical support, capacity-building and infrastructural needs of developing-country members in order to enable them to participate in the agreement and derive tangible benefits from such participation. For instance, aid-for-trade could become part of the agreement on environmental goods and services, making cooperation in trade conditional on resource and technology transfer.

The idea of a tie-in is not new, but so far its implications have been examined mainly in the context of bilateral negotiations. WTO negotiations on trade facilitation could create a precedent in the multilateral trading system by making aid-for-trade (almost) legally binding and trade concessions conditional upon the transfer of the necessary resources and technology. To define what necessary means in this particular context, a necessity test could be devised, identifying assistance needs. The main reason to believe this option could be agreeable to WTO Members is that potential recipients of assistance would undertake trade facilitation commitments in any case, with or without the negotiations. Would not the same logic apply to the environmental negotiations, especially if they were to turn to universally important objectives such as climate change mitigation?

Can the WTO be used to create incentives for developing countries? Cossy and Marceau (2009) stress the need to involve developing countries, both in the WTO and in the UNFCCC, while taking into account their development needs and priorities. The case law (EC - Tariff Preferences)[47] suggests that market access preferences can be conditioned on development-related criteria. The main question is whether or not preferences relating to climate change could be directly linked to sustainable development.

What about a tie-in within the WTO itself? The main question is whether trade rules and non-trade rules should be combined in the WTO in a different way than they are at present. The search for an answer would benefit tremendously from an analysis of the horizontal relationship among existing WTO agreements from the trade and environment perspective.

Cossy and Marceau (2009) point out that linking trade and climate change is impossible without linking trade and energy. The latter link involves competition and investment issues, and the WTO rules are still in the making in these areas. Put in Lamy's words, "…it is "markets" rather than "trade" that inform the core of policy concerns in the field of energy. Such policy concerns… have not really been the core focus of the GATT/WTO's work over the years." However, "…trade and trade rules are still relevant". The most intriguing question, and that is assuming the WTO has an increasingly important role to play, is whether the WTO should adapt existing rules to or, define new, specific rules for, energy?[48] And what if we were to replace the word "energy" with the word "the environment" or "climate change", for that matter? Would not the statement and the question still ring true?

In any case, the problems of scope and linkage are essentially political in nature. They can be solved only in the political arena, by political actors in the system, and not by quasi-technical discussions and negotiations. Some governments may well prefer to deal with issues they regard as remote from the WTO's agenda under different instruments or in other fora.

VI. The WTO Negotiations on Environmental Goods and Services: Need for a Change in Mindset Away from a Free-standing Sectoral Deal

Barbara Fliess
Senior Analyst, Trade and Agriculture Directorate, OECD[49]

» Given the cross-sectoral nature of environmental goods (EGs) the question arises as to whether a WTO sectoral agreement on EGs is a workable option. In theory, negotiating a sectoral agreement allows the simultaneous negotiation of tariffs and Non-Tariff Measures (NTMs), thus tackling all the measures affecting trade of EGs.

» However, the Information Technology Agreement and other agreements have shown that a sectoral approach may not be particularly well suited and effective for dealing with NTMs.

» The elimination of tariffs on EGs can be negotiated under WTO non-agricultural market access negotiations, as part of a broader tariff-cutting deal, using request-offer or other negotiating approaches, which should facilitate cross-product and cross-sector trade-offs.

» NTMs, particularly behind-the-border regulations with legitimate environmental policy intent but with a potential trade impact, must be negotiated in the context of rules-based negotiations, by seeking to either improve existing disciplines or elaborate new ones.

Given the cross-sectoral nature of environmental goods (EGs) included in the various lists that countries have proposed in the WTO negotiations, the question arises as to whether a sectoral agreement on EGs is a workable option. Not only is it an artefact to speak of an EG sector, but there are also many dissimilarities between the economic and political context in which the Information Technology Agreement (ITA) and other sectoral agreements were negotiated, and the context of negotiating an agreement for environmental goods and services (EGSs). EGSs clearly do not benefit from the many favourable conditions that made the ITA possible. Among them,

- industry is not pushing hard for trade liberalizing actions for EGs, not even in developed countries;
- unlike information and communication technologies (ICTs), markets for renewable energies and other EGs either do not yet exist or are weak in many developing countries;
- the sector is dynamic but not yet considered as vital as IT products to the broader economy;
- the number of developing countries that are major players in markets for EGs is smaller, although this depends on the products selected for consideration in the negotiations; and
- there are no deadline-setting events that would guide negotiations.

While the ITA has been successful in eliminating tariffs, it has failed to deal with barriers to trade related to non-tariff measures (NTMs)[50]. This is a lesson negotiators on environmental goods need to reckon with.

In theory, negotiating a sectoral agreement allows the simultaneous negotiation of tariffs and NTMs, thus tackling all the measures affecting trade of a product or group of products. However, the ITA and other agreements have shown that a sectoral approach may not be particularly well suited and effective for dealing with NTMs (perhaps along with tariffs). Some observers believe that focusing on a specific sector or list of related products would make it feasible to evaluate and negotiate specific barriers (tariffs and sector-specific NTMs) that affect that sector, and would bring together the most interested parties (the most important exporters and importers, or the critical mass), which in turn would drive the process of exchanging concessions. The use of the sectoral approach in international negotiations (regional, plurilateral or multilateral) is, however, relatively limited, and has never entailed an exhaustive coverage of actual or potential barriers to trade.

Why then should EGs be negotiated as a free-standing agreement? There appears to be nothing special about the types of tariff and non-tariff barriers to trade that these goods face, or the negotiating objectives. On the other hand, there is substantial political consensus that EGs (and services) should be given priority or special attention in current efforts to liberalize trade.

Concerning tariffs, instead of hoping that a sectoral deal covering tariff and non-tariff barriers to trade can be brought about, WTO Member economies could pursue tariff elimination or reduction under WTO non-agricultural market access negotiations, as part of a broader tariff-cutting deal. The objective would be to make sure that HS six-digit groups, including a certain percentage of environmental goods, are all part of the tariff package and are among the items with the deepest tariff cuts or tariff elimination. Dealing with them as part of a broad-based tariff reduction exercise using request-offer or other negotiating approaches should facilitate cross-product and cross-sector trade-offs.

When the issue is NTMs rather than tariffs, particularly behind-the-border regulations with potential trade effects, the goal of negotiation shifts from adopting a market-access perspective to a trade-rules one. The reason for this is compelling. Most NTMs are implemented with legitimate objectives or concerns of public policy in mind (e.g. technical regulations, sanitary standards or safety and health requirements). Here the challenge is to move towards a more harmonized approach to non-border regulation through the elaboration of rules that acknowledge the legitimacy of government intervention while seeking to minimise negative trade effects. Towards that end, governments commit to apply tests and other evaluation procedures, in addition to honouring general principles such as transparency and non-discrimination. The rationale for a rules-based approach to NTMs is that such measures should not be eliminated but regulated in order to ensure that governments select among available options those measures that interfere least with free trade.

Rules-based negotiations are not about exchanges of concessions in the tariff-reduction tradition. In general, NTM negotiations are difficult to manage with a request-offer approach and on a product-specific basis because of the intrinsic problems of quantifying those barriers and agreeing on equivalence among them. The process becomes even more complicated as the number of participants in the negotiations increases. At best, the request-offer method can be a complement to specific stages or parts of the negotiating process. For example:

- It could be applied at the beginning of the negotiating process to "clean" the most burdensome or urgent NTBs among parties and those that be easily identified.
- It could be applied as part of a sectoral negotiation for dealing with the elimination of important NTBs in specific sectors or subsectors. However, elimination is most often not the issue or goal.
- When rules are negotiated to regulate NTMs, request-offer negative or positive lists could be elaborated to exempt or apply the rules-based disciplines of the agreement to specific products or institutions (as in government procurement).
- The approach could be used to elaborate annexes of exemptions or specific rules.

There are two ways of dealing with NTBs for EGs of any kind: by seeking to either improve existing disciplines or elaborate new ones. In the former case, the task would be to identify what existing rules need clarification or amendments, leading to either procedural or substantive modifications. This requires technical homework. The latter case would require writing new rules from scratch.

In pursuing the first option, a starting point could be for standing committees overseeing the implementation and operation of WTO agreements on NTBs to set up working groups with, say, a two-year mandate to review measures or policies restricting trade in EGs, and recommend actions, including possible reforming of rules. For example, the WTO Agreement on Technical Barriers to Trade mandates or encourages meaures that facilitate trade by, inter alia, working towards harmonization of technical regulations, using international standards and diverse methods for recognizing the equivalence of trading partners' conformity assessment procedures. A work programme could ensure that these measures are being applied for designated groups of environmental goods. A similar process could be built into the work of the Committee responsible for the WTO Agreement on Subsidies and Countervailing Measures, as well as that of other committees. While the Committee on Trade and Environment Special Session (CTESS) may be reluctant to delegate its mandate, it lacks the specialized technical expertise to go beyond a non-technical discussion and an (overdue) NTB data-collection exercise, and negotiate on its own multiple NTBs simultaneously.

The second track – elaborating a set of new rules – makes sense only where or when the first track is unavailable or does not deliver.

One also needs to bear in mind that where NTBs are mainly a two-country issue, they can be settled bilaterally. Negotiations in a larger group are only necessary where NTMs have wider application.

It is important to note that NTBs faced by EGs are no different from those faced by other goods, as has been broadly confirmed by various studies, including work done by OECD.[51] With multilateral rules covering a vast array of barriers that are reported, the need for new agreements dealing specifically with EGs is not obvious. The reason why barriers to trade in environmental goods (and services) should be dealt with separately from existing agreements has yet to be explained.

VII. Environmental Goods: a Reality Check

Veena Jha
IDRC Research Fellow and Visiting Professorial Fellow, Warwick University

- In theory, liberalizing trade in environmental goods (EGs) and services could help developing economies build more environmentally sustainable economies. However, analysis shows that continued trade growth in EGs depends not only on policies supportive of freer trade in these goods and services, but also on viable domestic consumer markets for them.
- In fact, trade in EGs is restricted to a handful of middle-income countries, which have adequate purchasing power to sustain a dramatic rise in imports of EGs. Poor countries import almost no EGs, which points to the need for environment-related technical assistance projects to focus on poor countries, especially in Africa.
- Moreover, tariffs were found to be important in explaining imports of EGs by developing countries in only one category of EGs while the presence of high tariffs in two other categories was actually associated with more trade. Nevertheless, trade in almost all categories of EGs is found to be highly sensitive to growth in GDP and FDI as well as with the presence of technical assistance projects.
- This shows that while lowering tariffs may increase imports of EGs, several other factors may play a more decisive role. For instance, policies to promote viable domestic consumer markets for EGs as well as policies to improve the general competitiveness of exports may have a more crucial role to play in enhancing trade in EGs.

The growing importance of environmental issues has generated a parallel interest in evaluating the opportunity for trade in environmental goods (EGs) and services. Sustainable development strategies worldwide have contributed to the overall growth of the global environment industry, which is currently estimated at over $650 billion. However, trade in EGs and services is estimated to be only a tenth of that amount.

In theory, liberalizing trade in EGs and services could help developing economies build more environmentally sustainable economies. However, continued trade growth in this area depends not only on policies supportive of freer trade in these goods and services, but also on viable domestic consumer markets for them. Our analysis[52] shows that trade in EGs is restricted to only a handful of countries. Thus not all environmental hotspots are serviced by trade in EGs. The main reason behind this is the absence of viable markets.

A. Environmental goods do not reach all potential users

We analysed trade flows with regard to products on WTO's so-called "153 list " (WTO JOB(07) 54), which is a consolidated list of products proposed by the "friends" of liberalization of trade in environmental goods at the WTO. The study shows that the products on the list do not necessarily end up in the areas most in need of them. For example, environmental problems in Africa have reached critical levels, yet African countries import minimal amounts of EGs. This is because effective markets and paying capacity exist only in middle-income countries, which have seen a dramatic rise in imports of EGs. In addition, technical assistance or tied-aid projects appear to be directed to countries with adequate purchasing power. This gap in EGs imports in a large number of developing countries points to the need for technical assistance projects in poor countries, especially in Africa. Bilateral and multilateral donor assistance in this area has focused on the relatively higher income developing countries, notably Brazil, China, Mexico and the Republic of Korea.

The scope for addressing environmental problems by changing the set of EGs to be liberalized is limited, and there is no direct link between environmental problems and the list currently under discussion at the WTO. The picture is further complicated by the dual and often multiple uses of environmental goods (see also the article by Vikhlyaev in this Review).[53]

B. Restricting the scope of EGs

One way forward would be to initially liberalize only products that have an environmental end use. Our study shows that if environmental performance indicators were used to identify an environmental end use, EGs would be restricted to only a few categories of products from the "153" list of products. These categories include environmentally preferable products (EPPs), natural risk products, renewable energy, waste management, and clean-up, waste and potable water products. This list would also cover the category of products that have shown particular tariff sensitivity.

C. How important are tariffs?

Tariffs were found to be important in explaining imports of EGs by developing countries in only one category of products: heat and energy management products. Trade in renewable energy products was also sensitive to tariff reduction at the 5 per cent level. It is possible that these two categories comprise high-technology products, most of which tend to be imported by developing countries. Thus the initial list of EGs could be further narrowed to include only these sub-items for the initial round of liberalization. It should, however, be noted that the elasticity of these products with respect to tariffs is low, with a tariff reduction of 1 per cent leading to only a 0.15 per cent increase in trade.

For two other categories, the tariff response of trade in EGs is in the opposite direction. For both environmentally friendly products and natural-resource-based products, the higher the tariff, the higher is the trade. This could be attributed to the fact that trade in these products may be linked more directly to incomes rather than to tariffs: as incomes rise, trade in these categories increases, irrespective of higher tariffs.

D. What happens with rising GDP?

Trade in almost all categories of EGs is found to be highly sensitive to GDP: trade in air pollution equipment, EPPs , and products aimed at addressing natural risks increases as GDP increases., the Environmental performance index (EPI) surveys show that with an increase in GDP air pollution is the first to increase. In most countries, legislation to combat air pollution follows as GDP rises, which could account for the increase in trade in this category of products. Natural disaster mitigation also becomes a high priority when GDP rises, leading to an increase in trade in EGs in this category. As explained above, even amongst developing countries the preference for EPPs rises as incomes rise.

Trade in management of solid and hazardous wastes, clean-up and remediation, renewable energy products, and natural-resource-based products shows a significant negative correlation with GDP. While the generation of waste increases significantly with rising GDP, middle-income countries have been proactive in developing their own waste management systems. Equipment imports have generally been low, except in a few South-East Asian countries. For example, India and a number of other countries have relied mostly on indigenous solar and wind turbines. Their increase in GDP provides them with the necessary resources, often coupled with high levels of foreign direct investment (FDI), to develop and produce such equipment.

The most important justification for liberalizing trade in EGs is the improvement in developing- country environmental performance. For three categories of EGs, the correlation between the relevant environmental performance index (EPI) and trade is significant, at the 1 per cent level. These products, which are included in the categories of clean-up or remediation of soil and water, renewable energy, and heat and energy management, account for about 40 tariff lines. This high correlation could therefore be interpreted to imply that goods in these categories probably are being put to some environmental end use.

E. FDI growth correlates with trade in environmental goods

There appears to be a robust correlation between trade in environmental goods and FDI. As FDI increases, so too does trade in goods related to air pollution control, management of solid and hazardous waste and recycling systems, clean-up or remediation, renewable energy, natural risk management, and noise and vibration abatement equipment covered by the WTO list. This high correlation can be explained by the fact that most of these products have dual uses. Another explanation could be that higher levels of FDI are associated with better environmental practices, which necessitates the import of a wide range of environmental goods. Also, it is likely that the delivery of environmental services especially in these categories of services necessitates the import of these EGs. However, as the variable used is overall FDI, rather than FDI in specific categories of EGs, the most likely explanation is the first one. A counterintuitive result is seen in the category of EPPs, where the lower the FDI, the higher is the trade in EPPs. This result can be explained by the fact that the top EPP exporters are low-income Asian and African countries that have not attracted significant levels of FDI.

F. The importance of technical assistance

The most direct, significant and positive correlation is found with respect to technical assistance projects. This correlation is robust and positive for eight of the ten categories of EGs. In most cases the elasticities are also very high – significantly more than one – indicating the crucial role of technical assistance projects in explaining trade in EGs. The profile of these projects indicates that tied aid may be an important factor contributing to trade in EGs to developing countries. The lack of trade with low-income African countries could be because developed countries have very few projects in African countries. Increasing EG trade with Africa would therefore require the development of such projects.

G. Developing-country negotiating strategies

An analysis of factors influencing the import of EGs shows that while lowering tariffs may increase imports, several other factors may play a more decisive role. Supporting policies that improve the general competitiveness of exports is also likely to improve trade in EGs. Developing countries would not necessarily benefit in either environmental or trade terms from fast-track liberalization of environmental goods.

Dynamic comparative advantage appears to be shifting in favour of developing countries for a number of categories of goods identified in the "153" list. In the medium to long term, developing countries are likely to benefit from tariff liberalization. However, as developed countries already have low tariffs, developing countries may find it more beneficial to focus on non-tariff barriers. With a growing comparative advantage it will be in developing countries' interests to examine the role that non-tariff barriers play in their export markets. Since only a handful of developing countries feature among the top 10 importers and exporters of EGs, these players could usefully engage in a request offer approach to exchange market access concessions. In this way, while the benefits may be multilateralized, the cost of liberalization will have to be borne by only a few players. These would be the very players who have a lot more to gain through liberalization.

H. Environmental services

The link between trade in EG and ES has been widely acclaimed. For negotiating purposes, it is important to pursue liberalization of EGs and ESs separately; the link should not be used to slow down liberalization in either of these two areas.

Liberalization of ES particularly in public utilities needs further evaluation. Experience with privatization has been mixed. In many cases, the delivery of public services has not improved with privatization and has exacerbated social exclusion.

These caveats do not imply that trade liberalization in ES should be restricted, but rather that liberalization will not deliver the expected benefit unless a supportive infrastructure such as regulations and community participation is in place. The supportive infrastructure would be equally important for absorbing and disseminating environmentally sound technologies.

Another area of ES which has been little explored is that of outsourcing environmental consultancy services. The comparative advantage of developing countries in this area needs to be carefully investigated.

Notes

1 A survey of rural households in India found that 96 per cent of the households use biomass energy together with other energy sources (kerosene and liquefied petroleum gas (LPG)) to meet their needs. The study found that 5 per cent of adults suffer from bronchial asthma, 16 per cent from bronchitis, 8.2 per cent from pulmonary tuberculosis and 7 per cent from chest infection (Parikh et al., 2005).

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

3 Paragraph 9(a) of the Plan; available at: www.un.org/esa/dsd/dsd_aofw_ene/ene_index.shtml.

4 See, for instance, UNDP, La Plate-forme multifonctionnelle: introduire des sources d'énergie, ouvrir la voie au changement pour le bien des communautés rurales du Burkina Faso – a UNDP-supported programme in Burkina Faso; available at: www.pnud.bf/DOCS/Plate-forme_FRA.pdf, January 2009.

5 The World Bank (2006a) 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.

6 The Millennium Project was commissioned by the United Nations Secretary-General in 2002 to develop a concrete action plan for the achievement of the MDGs. In 2005, the independent advisory body headed by Professor Jeffrey Sachs, presented its final recommendations to the Secretary-General in a synthesis volume entitled, Investing in Development: A Practical Plan to Achieve the Millennium Development Goals. For further information, see: www.unmillenniumproject.org/.

7 The Kenyan GNI per capita was $1,550 in 2007 (World Bank country profiles, available online at: www.worldbank.org/countries.

8 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 (CIMES/RP).

9 Similar structures exist in some other West African countries, and are supported by the White Paper for a Regional Policy: Geared toward increasing access to energy services for rural and periurban populations in order to achieve the Millennium Development Goals of the Economic Community of West African States (ECOWAS). See: www.energyandenvironment.undp.org/undp/indexAction.cfm?module=Library&action=GetFile&DocumentAttachmentID=1675.

10 Examples of projects were drawn from www.climatefundsupdate.org.

11 See: www.gefweb.org/projects/Focal_Areas/climate/climate.html.

12 See: www.lightingafrica.org/.

13 See: www.cdmpaipeline.org/cdm-projects-type.htm#2.

14 See UNFCCC, National adaptation programmes of action: Index of NAPA projects by country, at: http://unfccc.int/files/adaptation/application/pdf/napa_index_country.pdf; and UNFCCC, National adaptation programmes of action: Index of NAMA projects by sectors, at: http://unfccc.int/files/national_reports/napa/application/pdf/napa_index_sector_march_09.pdf

15 By comparison, Germany, a leader in the exploitation of wind energy, added some 2 GW of newly installed capacity in 2009 (see Der Tagesspiegel, China macht mehr Wind als die USA, ,24 July 2009). On the future outlook, see Global Wind Energy Council, US and China in race to the top of global wind industry, 2 February 2009; available at: www.gwec.net/index.php?id=30&tx_ttnews[tt_news]=177.

16 See Reuters, China seen surging to top wind turbine maker in 09. (Interview with Steve Sawyer, secretary of the Global Wind Energy Council), January 8, 2008; available at: www.reuters.com/article/latestCrisis/idUSL0773451. Among other things, Sawyer called on member companies to prepare "for the onslaught of relatively inexpensive Chinese turbines onto the world market," which he thought was imminent.

17 On the Dongfang deal, see Reuters, Dong Fang Electrical Machinery and The Switch Sign Windpower Generator Co-operation Agreement, June 30, 2008; available at: www.reuters.com/article/pressRelease/idUS115462+30-Jun-2008+MW20080630.

18 For the targets, see the website of TEDA (Tianjin Economic and Technological Development Area) at: http://en.investteda.org/aboutteda/keyindustriesbrief/wind/default.htm.

[19] See also Baoding High-Tech Industry Development Zone website at: www.bdgxq.cn/english/jjfz_eng.asp.

[20] Cielo Wind Power press release, October 29, 2009, announcing a joint venture with Shenyang Power Group to build wind farm in Texas; available at: www.cielowind.com/news/press-releases/us-renewable-energy-group-china%E2%80%99s-shenyang-power-group-and-cielo-wind-power-to-develop-a-600-mw-wind-farm-in-texas.

[21] GE press release, GE Drivetrain Technologies signs LOIs with A-Power to supply 900 wind turbine gearboxes and establish joint venture to build wind turbine assembly facility, 12 January 2009; available at: www.genewscenter.com/content/detail.aspx?releaseid=5471&newsareaid=2&menusearchcategoryid=; and PR Newswire Asia, A-Power Energy Generation Systems Ltd. to acquire 1.5MW wind turbine proprietary technology from Shenyang Huaren Wind Power Technology Development Co., Ltd., 28 July 28 2009; available at: www.prnasia.com/pr/09/07/09500311-1.html; PR Newswire Asia, A-Power Energy Generation Systems Ltd. to develop a 19.5MW wind farm in Shandong Province, 14 October 2009; available at: www.prnasia.com/pr/09/10/09711711-1.html.

[22] The United States Trade Representative rejected complaints that the EU-United States list consisted only of products of export interest to industrialized countries, pointing out that in 2006 the United States was in fact a net importer of the 43 products, with $18 billion in imports of such products, surpassing exports by $3 billion, and citing China and Mexico as the two top sources for those products (ICTSD, 2007c).

[23] Van der Gaast and Begg (2009) argue that programmatic CDM is highly suited to energy efficiency improvement projects in households (e.g. cooking, lighting) and industry (e.g. one technology applied within an industrial sector at different locations but under similar circumstances).

[24] In liberalizing trade in EGS, priority should be given to products, technologies and services used in small-scale CDM projects and programmatic CDM. In other words, such products, technologies and services should be included in any list of EGSs for accelerated liberalization. While the motivation would be to facilitate small-scale CDM projects and programmatic CDM, any agreed tariff reduction or elimination would apply to all these EGSs, irrespective of whether these are used for CDM projects. This makes it conceptually different from the Indian proposal for a project-approach that ties the liberalization of any EGS to specific projects.

[25] In a letter to United States President Barack Obama on 3 August 2009, the National Foreign Trade Council and eight other United States business groups urged his Administration to “use all possible channels” to pursue an agreement on reducing barriers to trade in EGSs, even if that meant going outside the Doha Round (Palmer, 2009).

[26] It would make more sense in the context of climate change mitigation to define critical mass as a share of emissions rather as a share of trade. After all, any agreement on climate-friendly goods aims to cut GHG emissions by providing more choices at lower costs. However, this approach depends on how such climate-friendly goods are produced and what goods they would replace. However, it is much more difficult to calculate emissions than to calculate trade value/volume, and it is an area unfamiliar to WTO negotiators. Taken together, while the approach sounds very appealing theoretically, these complications would make it hard to implement, in practice.

[27] An analysis by Jha (2008) of 84 energy supply products in the Friends’ 153 EGS list reveals that only 30 per cent of those products are sensitive to a tariff reduction.

[28] The term renewables is used here and throughout the text to signify goods, equipment and technologies used in conjunction with renewable energy sources and biofuels.

[29] See Pascal Lamy , “WTO culture of international trade cooperation is relevant to the energy sector”, a speech delivered at a conference organized by the Centre for Trade and Economic Integration (CTEI) at the Graduate Institute of International and Development Studies, Geneva, 22 October 2009.

[30] Statement by the WTO Director General Pascal Lamy at a joint press conference with Australia’s trade minister Simon Crean after an informal meeting of trade ministers in Paris on 25 June 2009, www.wto.org/english/news_e/news09_e/dgpl_25jun09_e.htm.

[31] As tracked by the Renewable Energy International Law Project (REILP) in 2005. Quoted from an informal briefing paper for UNCTAD Expert Meeting on Strengthening Participation of Developing Countries in Dynamic and New Sectors of World Trade: Trends, Issues and Policies, Geneva, February, 2005.

[32] Swedish National Board of Trade, Trade aspects of biofuels, 2007; available at: www.kommers.se/upload/Analysarkiv/In%20English/Trade%20Aspects%20of%20Biofuels.pdf .

[33] For example, some of the major components of a wind turbine are rotors, drive trains and generators, while

subcomponents are even more diverse, such as blades, high-speed and low-speed shafts, gear boxes, brakes and plastic products. These intermediate goods are identifiable in the Harmonized System (HS), which classifies traded products, as ex-6 digit items; some, such as rotors and generators, are specific to wind energy, while others, such as gearing equipment, have multiple uses.

34 Market-creation measures underwrite the costs of introducing renewables into the market, improving technical performance and encouraging the development of the industry.

35 The Harmonized Commodity Description and Coding Systems generally referred to as "Harmonized System" or simply "HS" is a multipurpose international product nomenclature developed by the World Customs Organization (WCO).

36 These factors are not specific to *renewables*, of course.

37 Hydraulic turbines >10 MW (8410.13) are generally not considered environmentally friendly.

38 In the trade negotiators' parlance, ex-outs are goods that are not identified separately at the 6-digit level (internationally harmonized) of the Harmonized Commodity Description and Coding Systems and have to be identified in national tariff schedules at the 8- or 10-digit level.

39 While one list in the ITA is relatively straightforward and contains few ex-outs, there has been extensive ongoing technical work to correct some of the problems created with a second list which is essentially all ex-outs. After many years, a significant number of these have been rectified through changes to the HS nomenclature (internationally harmonized 6 digits) by the World Customs Organization (WCO).

40 The negotiating history of the ITA is described by Barbara Fliess, Pierre Sauvé, in: Of Chpis, Floppy Discs and Great Timing: Assessing the WTO Information Technology Agreement, Paris, Institut Francais des Relations Internationales, 1998.

41 European Communities - Measures Affecting Asbestos and Asbestos-Containing Products - AB-2000-11 - Report of the Appellate Body, WT/DS135/AB/R.

42 The negotiations on financial services could deal with the status and treatment of tradable renewable energy certificates in the future.

43 The Services Sectoral Classification List, MTN.GNS/W/120, 10 July 1991, generally known as W/120, contains three specific sub-categories that have been identified as part of a potential "energy services" sector, namely "services incidental to mining", "services incidental to energy distribution" and "pipeline transportation of fuels". Those activities constitute sub-categories of other services sectors listed in W/120 (i.e. business services for the first two and transport services for the latter). It is not the classification that determines the scope of GATS though.

44 It has been argued that different activities in the energy chain exist depending on the type of energy involved. Thus a definition of the sector could consist of separate subsectors for each type of energy source involved. The alternative to that suggestion would be to identify the services of the energy sector as a whole regardless of the source of energy, which has been referred to as an energy-neutral approach.

45 See the "Proposal for a result under paragraph 31 (iii) of the Doha Ministerial Declaration", Non Paper by the European Communities and the United States JOB(07)/193/Rev.1, 6 December 2007 Committee on Trade and Environment Special Session Council for Trade in Services Special Session.

46 For an interesting discussion see The Multilateral Trade Regime: Which Way Forward? The report of the first Warwick Commission. University of Warwick, 2007.

47 European Communities - Conditions for the Granting of Tariff Preferences to Developing Countries, WTO, WT/DS246/AB/R, 2004.

48 Pascal Lamy's speech , "WTO culture of international trade cooperation is relevant to the energy sector", at a conference organized by the Centre for Trade and Economic Integration (CTEI) at the Graduate Institute of International and Development Studies, Geneva, 22 Octobre 2009, www.wto.org/english/news_e/sppl_e/sppl139_e.htm.

49 The views expressed in this paper are the author's alone, and do not necessarily reflect the views of the OECD or of its Members.

50 The author prefers the term Non-Tariff Measures to Non-Tariff Barriers (NTBs).

51 See Barbara Fliess and Joy Kim, *Business perceptions of non-tariff barriers facing trade in selected environmental goods and services,* OECD Trade and Environment Working Paper 2007-02, Parts I and II, OECD, Paris.

[52] This short commentary is a summary of the paper prepared by the author for the International Centre for Trade and Sustainable Development, Geneva in 2008. For downloading the full paper visit the ICTSD website at: http://ictsd.net. ICTSD will be publishing another paper on environmental goods, climate change and the renewable energy sector by the same author later in 2009. Further work on trade in EGs in the buildings and transport sector is also planned.

[53] For example, while the Environmental Business International sets a market value of over $650 billion for EGs, it states that only about 15 per cent of that value may be traded. The value of traded EGs on the WTO "153" list is about $430 billion. This implies that there are several multiple-use products on the "153" list. This points to the need to further restrict the scope of EGs.

References

Alavi R (2007). An overview of key markets, tariffs and non-tariff measures on Asian exports of select environmental goods. ICTSD Trade and Environment Series Issue Paper No.4. Geneva, ICTSD.

Barnes D and Halpern J (2000). The role of energy subsidies. In: *Energy and Development Report.* Washington, DC, World Bank: 60–66; available at: www.worldbank.org/html/fpd/esmap/energy_report2000/ch7.pdf.

Beijing Gao Hua Securities Company Limited (2009). Favorable tailwind; initiate on China High Speed (Buy), Goldwind, October 23; available at: www.e696.com/articles.aspx?id=1057653&gateid=011203.

Bhandari O (2006). Socio-economic impacts of rural electrification in Bhutan. Asian Institute of Technology, Master thesis, 24 May.

Brack D (1996), *International Trade and the Montreal Protocol*. London, The Royal Institute of International Affairs and Earthscan.

Changliang X and Song Z (2009). Wind energy in China: Current scenario and future perspectives. *Renewable and Sustainable Energy Reviews*, 13(8): 1966–1974.

Conconi P and Perroni C (2002). Issue linkage and issue tie-in in multilateral negotiations. *Journal of International Economics*, 57: 423–447.

Cossey M and Marceau G (2009). Institutional challenges to enhance policy coordination: How WTO rules could be utilised to meet climate objectives, in: Cottier T, Nartova O and Bigdeli Sadeq Z, eds. *International Trade Regulation and the Mitigation of Climate Change*. Cambridge, World Trade Forum.

Cottier T (2006a). Alternative approaches to negotiating environmental goods: Select legal issues. Working Paper on Environmental Goods. Geneva, UNCTAD.

Cottier T (2006b). From progressive liberalization to progressive regulation in WTO law. *Journal of International Economic Law*, 9(4): 779–821.f.

Cottier T and Baracol-Pinhao D (2008). The WTO negotiations on environmental goods and services: A potential contribution to the Millennium Development Goals, UNCTAD/DITC/TED/2008/4, Geneva.

Cottier T and Baracol-Pinhao D (2009). Environmental Goods and Services: The Environmental Area Initiative Approach and Climate Change. In: Cottier T, Nartova O and Bigdeli Sadeq Z, eds. *International Trade Regulation and the Mitigation of Climate Change*. Cambridge, World Trade Forum.

Delman, J and Yong C, *"Nordic Collaboration with China in Energy Research and Development"*. Copenhagen, Nordic Institute of Asian Studies, November: 100–101.

Deyer I, and Hindley B, Trade in Information Technology: Adapting the ITA to the 21st Century Technological Change; available at www.ecipe.org.

Finanzen Net (2009). AMSC and Sinovel sign $100 million follow-on electrical components contract for 3 megawatt wind turbines. September 20; available at: www.finanzen.net/nachricht/AMSC-and-Sinovel-Sign-100-Million-Follow-On-Electrical-Components-Contract-for-3-Megawatt-Wind-Turbines-677046.

Fliess B, and Sauvé P, (1998) Of chips, floppy discs and great timing: Assessing the WTO Information Technology Agreement, Paris, Institut Francais des Relations Internationales.

G-8 (2008). Finance ministers' statement on the climate investment funds (the Clean Technology Fund and the Strategic Climate Fund), Osaka, 14 June. available at: http://go.worldbank.org/58OVAGT860

G-8 (2009). Joint Statement by the G-8 Energy Ministers, the European Commissioner and the Energy Ministers of Algeria, Australia, Brazil, China, Egypt, India, Indonesia, 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: www.g8energy2009.it/pdf/Session_II_III_EC.pdf.

Gardiner G (2008). Wind blade manufacturing, part I: M and P innovations optimize production. In: *High Performance Composites*, October 21; available at: www.compositesworld.com/articles/wind-blade-manufacturing-part-i-m-and-p-innovations-optimize-production.aspx.

Global Wind Energy Council (undated). China. Available at: www.gwec.net/index.php?id=125.

Government of India (2006). Report of the Expert Committee on Integrated Energy Policy. Planning Commission. August. New Delhi; available at: http://planningcommission.nic.in/reports/genrep/rep_intengy.pdf.

Hamwey R (2005). Environmental goods: where do dynamic trade opportunities for developing countries lie?

Working Paper, Centre for Economic and Ecological Studies, Geneva.

Howse R. (2009), World Trade Law and Renewable Energy: The Case of Non-Tariff Barriers, UNCTAD/DITC/TED/2008/5, New York and Geneva.

Howse R and van Bork P (2006). Options for liberalizing trade in environmental goods in the Doha Round. Trade and Environment Series Issue Paper No.2, ICTSD, Geneva.

ICTSD (2007a). EU, US call for eliminating trade barriers to climate-friendly goods and services, Geneva, 18 December; available at: http://ictsd.net/i/news/biores/9151/.

ICTSD (2007b). Brazil, Peru discuss new ideas on environmental goods liberalisation. Geneva, 16 November; available at: http://ictsd.net/i/news/biores/9144/.

ICTSD (2007c). Bali Climate Conference: the next two years will tell. November; available at: http://ictsd.net/i/news/bridges/3159/.

ICTSD (2008). Liberalization of trade in environmental goods for climate change mitigation: the sustainable development context, Geneva.

IEA (2002). Energy and poverty. In: *World Energy Outlook*. Paris, November; available at: www.iea.org/weo.

IEA (2006). Energy for cooking in developing countries. In: *World Energy Outlook*. Paris; available at: www.iea.org/weo.

IEA (2007). Renewables in global energy supply. IEA Fact Sheet. Paris, January; available at: www.iea.org/textbase/papers/2006/renewable_factsheet.pdf.

IEA (2008). Prospects in oil- and gas-exporting sub-Saharan African countries: Could their resources alleviate energy poverty? In: *World Energy Outlook.* Paris; available at: www.worldenergyoutlook.org/docs/weo2008/WEO_2008_Chapter_15.pdf.

IEA (2009). The impact of the financial and economic crisis on global energy investment. IEA Background paper for the G-8 Energy Ministers Meeting in Rome, 24-25 May 2009; available at: www.g8energy2009.it/pdf/IEA_Paper_for per cent20G8-Impact_of_the_crisis_on_energy_investment.pdf.

IEG (Independent Evaluation Group of the World Bank) (2008). The welfare impact of rural electrification: A reassessment of the costs and benefits: an IEG impact evaluation. IEG Study Series. Washington, DC; available at: http://go.worldbank.org/RLWYTOPIO0.

Jha V (2008). Environmental priorities and trade policies for environmental goods: a reality check. Trade and Environment Series Issue Paper No.7, ICTSD, Geneva.

Karekezi S, Kimani J and Wambile A (2007). Renewables in Africa. Energy experts' concept paper. Nairobi, Energy, Environment and Development Network for Africa.

Koot E (2006). Chinese city of Baoding stimulates development of renewable energy sector. November; available at: www.solarplaza.com/content/pagina/SolarPlaza%20Articles/44213.

Lallement D (2008). Energy options for livelihood needs of the poor and women in an era of high fossil fuel prices. Discussion paper for the High Level Regional Policy Meeting on Networking Towards Gender and Poverty Sensitive Energy Policies 3-4 November 2008, United Nations Conference Centre, Bangkok

Lamy P (2008). A consensual international accord on climate change is needed. Paper presented at the Temporary Committee on Climate Change, The European Parliament, Brussels, 29 May; available at: www.wto.org/english/news_e/sppl_e/sppl91_e.htm.

Li Junfeng and Ma Lingjuan (2009). Chinese renewables. Status report. REN21, October: 16; available at: www.ren21.net/pdf/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf

Liu Li (undated). Development and practice: Strategic consideration on the innovation clusters in Tianjin Hi-Tech Industry Park. Power point presentation at: www.ctibo.org/IMG/ppt/02_Tianjin.ppt.

Liu Yinglin (2006). Made in China, or Made by China? Chinese wind turbine manufacturers struggle to enter own market. Worldwatch Institute, 19 May; available at: www.worldwatch.org/node/3931.

Martinot E and Reiche K (2000). Regulatory approaches to rural electrification and renewable energy: case studies from six developing countries. World Bank working paper, June; available at: www.martinot.info/Martinot_Reiche_WB.pdf.

May H, Weber T and Weinhold N (2008). The new collection. *New Energy*, no. 6: 3; available at: www.newenergy.info/index.php?id=1821.

McElroy Michael B et al. (2009). Potential for wind-generated electricity in China, *Science,* vol. 325: 1378–1380, 11 September.

Ministry of Finance (2008). Announcement on adjustment of tax incentive policies for imported large power wind turbine system key components and raw materials, April 24; available at: www.cresp.org.cn/english/encontent.asp?id=994.

Modi, V., McDade S., Lallement D., and Saghir J. (2006). Energy and the Millennium Development Goals. New York: Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project, and World Bank, available at: available at: www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf.

NDRC (National Development and Reform Commission) (2007). Medium and Long-Term Development Plan for Renewable Energy in China. Abbreviated English draft version, September: 12; available at: www.martinot.info/China_RE_Plan_to_2020_Sep-2007.pdf.

NDRC (undated). No overcapacity of windpower.

New Energy Focus (2009). Wind turbine development moving on from pursuit of size, 22 January; available at: www.newenergyfocus.com/do/ecco.py/view_item?listid=1&listcatid=32&listitemid=2161.

Ng Eric (2009). Wind power turbine makers head for industry shake-up. *South China Morning Post*, 22 September.

OECD (2006). Key Issues of Environmental Goods. Report of the Joint Working Party on Trade and Environment, COM/ENV/TD(2006), Paris, 30 May.

OECD and IEA (2004). Renewable energy, market and policy trends in IEA countries. Paris.

Palmer D (2009). Remove environmental goods talks from Doha: U.S. groups. *Reuters,* 4 August; available at: www.reuters.com/article/GCA-GreenBusiness/idUSTRE5725Z520090804.

Parikh JK et al. (2005). Lack of energy, water and sanitation and its impact on rural India. In: Parikh Kirit S and Radhakrishna R, eds. *India Development Report 2004-2005.* New Delhi, Oxford University Press (cited in Government of India, 2005).

Penn Energy (undated). The Switch now offers the widest range of permanent magnet packages available for wind power; available at: www.pennenergy.com/index/products/power/product-display/365733/articles/electric-light-power/products/transmission-and_distribution/2009/07/the-switch-now-offers-widest-range-of-permanent-magnet-packages-available-for-wind-power.html.

Porter Michael (2000). Location, competition, and economic development: local clusters in a global economy, *Economic Development Quarterly*, 14(1): 16.

Reiche K, Covarrubias A and Martinot E (2000). Expanding electricity access to remote areas: off-grid rural electrification in developing countries. In: Guy Isherwood, ed. *WorldPower 2000.* London, Isherwood Production Ltd: 52–60; available at: www.martinot.info/Reiche_et_al_WP2000.pdf.

Reinvang Rasmus et al. (2008). A global “electric valley” for sustainable energy production? A litmus test for the world’s commitment to renewable energy. World Wide Fund for Nature China Programme Office, April; available at: http://assets.wwf.no/downloads/baoding_intro_report_final_2008.pdf.

REN21 (2007). *Renewables 2007: Global Status Report.* Paris, REN21 Secretariat and Washington, DC, Worldwatch Institute; available at: *www.ren21.net/globalstatusreport.*

REN21 (2009). *Renewables 2009: Global Status Report.* Paris, REN21 Secretariat and Washington, DC, Worldwatch Institute; available at: *www.ren21.net/globalstatusreport.*

Rudolf JC (2009). Chinese and U.S. partners to build big West-Texas wind farm. *The New York Times*, October 29.

Schwartz L and Hodum R (2008), China’s wind power industry: localizing equipment manufacturing. *Renewable Energy World. com,* July, at: www.renewableenergyworld.com/rea//news/article/2008/07/chinas-wind-power-industry-localizing-equipment-manufacturing-53076.

Steenblik R (2005). Environmental goods: a comparison of the APEC and OECD lists. OECD Joint Working Party on Trade and Environment, COM/ENV/TD (2003) 10/FINAL. Paris, OECD; available at: www.oecd.org/dataoecd/44/3/35837840.pdf.

UNCTAD (2004). UNCTAD’s work on environmental goods and services. Briefing note for the WTO Committee on Trade and Environment, Special Session, TN/TE/INF/7, Geneva, 5 October.

UNCTAD (2005a). Report of the Expert Meeting on Strengthening Participation of Developing Countries in Dynamic and New Sectors of World Trade: Trends, Issues and Policies, TD/B/COM.1/EM.26/3, UNCTAD, Geneva, February.

UNCTAD (2005b). Environmental goods: identifying items of export interest to developing countries. CBTF briefing note, Geneva.

UNDP (2009). Green jobs for the poor: a public employment approach. UNDP Poverty Reduction Discussion Paper (by Lieuw-Kie-Son Maikel R), April. New York; available at: www.undp.org/poverty/docs/sppr/docs-propoor/PG-2009-002-discussion-paper-green-jobs.pdf.

UNEP (2008). Green jobs: Towards decent work in a sustainable, low-carbon world. Green jobs policy messages and main findings for decision makers. Available at: www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf.

UNEP Risoe Center (2009). CDM and JI pipelines by August 1. Denmark; available at: www.cdmpipeline.org/Publications/CDMPipeline.xls.

Van der Gaast W and Begg K (2009). Enhancing the role of the CDM in accelerating low-carbon technology transfers to developing countries. *Carbon and Climate Law Review*, 3(1): 58–68.

Vikhlyaev A (2003). Environmental goods and services: Defining negotiations or negotiating definitions. In: UNCTAD, *Trade and Environment Review 2003*, Geneva: 33–60.

WHO (2000). Indoor air pollution in developing countries: a major environmental and public health challenge (by Bruce N, Perez-Padilla Albalak R). *Bulletin of the World Health Organization*, 78 (9): 1078-1092. Geneva; available at: www.who.int/docstore/bulletin/pdf/2000/issue9/bul0711.pdf.

World Bank (2000). Regulatory approaches to rural electrification and renewable energy: case studies from six developing countries World Bank Working Paper (by Martinot E. and Reiche K). Washington, DC, June; available at: www.martinot.info/Martinot_Reiche_WB.pdf.

World Bank (2006a). Energy poverty issues and G8 actions, 2 February; available at: http://194.84.38.65/files/esw_files/Energy_Poverty_Issues_Paper_Russia_G8_eng_summary.pdf.

World Bank (2006b). Technical and economic assessment of grid, mini-grid and off-grade electrification technologies. ESMAP Technical Paper 121/07. Washington, DC, ESMAP; available at: http://siteresources.worldbank.org/EXTENERGY/Resources/336805-1157034157861/electrificationAssessmentRptAnnexesFINAL17May07.pdf.

World Bank (2007). *International Trade and Climate Change: Economic, Legal and Institutional Perspectives*, Washington, DC.

World Bank (2008a). *World Development Report: Agriculture for Development.* Washington, DC; available at: www.worldbank.org/wdr2008.

World Bank (2008b). Designing sustainable off-grid rural electrification projects: Principles and Practices. Washington, DC; available at: http://siteresources.worldbank.org/EXTENERGY2/Resources/OffgridGuidelines.pdf?resourceurlname=OffgridGuidelines.pdf

World Bank (2008c). Low carbon energy projects for development in sub-Saharan Africa: Unveiling the potential, addressing the barriers. World Bank Report, Washington, DC; available at: http://go.worldbank.org/VXW3K1BWD0.

World Bank (2009) Protecting progress: the challenge facing low-icome countries in the global recession, Background paper prepared by World Bank Group staff for the G-20 Leaders' Meeting, Pittsburgh, USA, September 24–25.

Yulin He and Xinping Chen (2009). Wind turbine generator systems – The supply chain in China: Status and problems. *Renewable Energy*, 34, December: 2892–2897.

Zhang Xiliang et al. (2009). China's wind industry: policy lessons for domestic government interventions and international support. *Climate Policy*, 9(5): 556–557.

Zhang ZX (1998). Greenhouse gas emissions trading and the world trading system, *Journal of World Trade*, 32(5): 219–239.

Zhang ZX (2004). *Open trade with the U.S. without compromising Canada's ability to comply with its Kyoto Target.* Journal of World Trade, 38(1): 155–182.

Zhang ZX (2008). Asian energy and environmental policy: Promoting growth while preserving the environment.

Energy Policy, 36(10): 3905–3924.

Zhang, ZX (2009a), Multilateral trade measures in a post-2012 climate change rregime?: What can be taken from the Montreal Protocol and the WTO?, *Energy Policy*, 37(12): 5105-5112.

Zhang ZX (2009b). Energy policy in China in the transition to low-carbon economy. Presentation at the East-West Center/Korean Energy Economics Institute Conference on Fossil Fuels to Green Energy: Policy Schemes in Transition for the North Pacific, Honolulu, Hawaii, 20–21August.

Zhang ZX and Assunção L, (2004). Domestic climate policy and the WTO. *The World Economy*, 27(3): 359–386.