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LIBERALISATION OF TRADE IN RENEWABLE-ENERGY PRODUCTS AND ASSOCIATED GOODS: CHARCOAL, SOLAR PHOTOVOLTAIC SYSTEMS, AND WIND PUMPS AND TURBINES

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ABSTRACT

Numerous studies and events over the past several years have stressed the importance of eliminating barriers to trade in renewable forms of energy and the technologies used to exploit them, as part of a broader strategy to reduce dependence on more-polluting and less secure energy sources. This paper examines the implications of liberalising trade in renewable energy, focussing on several representative fuels and technologies (charcoal, solar photovoltaic systems and their complements, and wind turbines and wind pumps). Eliminating tariffs on renewable energy and associated goods — which are 15% or higher on an *ad valorem* basis in many developing countries — would reduce a burden on consumers of energy, particularly people living in rural areas of developing countries, as it is in such areas that many renewable-energy technologies are making, and are likely to make, their greatest contribution. Manufacturers located in OECD countries would benefit from increased trade in renewable-energy technologies and components, but so would a growing number of companies based in developing countries. The elimination of tariffs would also help to level the playing field between aid-financed goods, which often benefit from tariff waivers, and goods imported through normal market transactions, which often do not. For the maximum benefits of trade liberalisation in renewable-energy technologies to be realised, however, additional reforms may be required in importing countries' domestic policies, especially those affecting the electricity sector in general, rural electrification in particular, and the environment.

JEL Classifications: F14, F18, Q42, Q48, Q56

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Executive Summary

Numerous studies and events over the past several years have stressed the importance of eliminating barriers to trade in renewable forms of energy and the technologies used to exploit them, as part of a broader strategy to reduce dependence on more-polluting and less secure energy sources. An opportunity to achieve such an outcome at the multilateral level has arisen in the form of a negotiating mandate given to members of the World Trade Organization (WTO) in the Ministerial Declaration adopted at the meeting of WTO ministers in Doha, Qatar, in November 2001. Paragraph 31 of that mandate states "With a view to enhancing the mutual supportiveness of trade and environment, we agree to negotiations, without prejudging their outcome, on: … (iii) the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services."

At issue is the question, "What is an environmental good?" In the absence of an official definition, the approach taken so far by WTO members has been to put forward positive lists of goods for possible inclusion in a final list to be agreed to eventually by all. Several WTO members have already included certain technologies relating to renewable energy — such as solar photovoltaic cells and wind turbines — in the lists they have submitted to the negotiating groups. Many of these technologies were also included in the lists of environmental goods prepared by the Asia Pacific Economic Co-operation (APEC) forum and by the OECD, which have often been referred to as useful starting points for discussion. They were included, basically, because they produce less or no air pollution or CO_2 emissions during use.

The aim of this paper is to examine the implications of liberalising trade in renewable energy in general and several representative fuels and technologies in particular. As part of the analysis, the paper re-examines the goods included in the extant lists and identifies several forms of renewable energy that have not been included in the lists circulated to date (fuel wood; logs and pellets made from pressed sawdust; charcoal), additional technologies (wind pumps; Sterling engines), and several components of renewable-energy-based systems (solar storage batteries; charge controllers; inverters; anemometers). Some of these goods are separately identified in the World Customs Organization's Harmonized Commodity Description and Coding System ("the HS"), and the rest are not — i.e., are "ex outs" in the language of trade negotiations.

The report examines three groups of products related to renewable energy: charcoal, solar photovoltaic (PV) systems and their complements, and wind turbines and wind pumps. These product groups were chosen as representative of three of the major forms of renewable energy, and because they span the range of common applications. Charcoal is an inferior good, used predominantly by people living on very low incomes; solar PV systems are particularly suited for supplying off-grid power to households and communities pulling themselves out of poverty; and wind turbines are one of the fastest-growing segments of the global market for grid-connected power plants.

Because some renewable-energy technologies and their components are not separately identified at the harmonised, 6-digit level in the HS, identifying current patterns of trade for particular goods is not always straight-forward. Based on what information can be obtained on trade in renewable energy and associated technologies, however, it can be said with a high degree of confidence that most of the trade in renewables still takes place among OECD countries. The main exception is trade in charcoal. Nonetheless, both consumption and production of renewables is increasing outside the OECD area, particularly in

developing countries. Consumption is driven by the attractiveness of several types of renewable-energy-based systems for providing electric power to households in rural areas. These form the majority of the 1.6 billion people living in developing countries without access to electricity. Many renewable-energy projects are underwritten in part (sometimes in large part) by development assistance agencies, non-governmental organisations, or multilateral lending agencies. Purchases of technologies for generating electricity from renewable energy on a large scale, notably geothermal power plants and large wind turbines, are also experiencing growth in several developing countries, aided by new information identifying areas of high resource potential. There appears, as well, to be a strong association between investment in manufacturing plants in developing countries and growth in the number of renewable-installations, although the causal relationship may be two-way.

Eliminating tariffs on renewable energy and associated technologies — which are 15% or higher on an *ad valorem* basis in many developing countries — would reduce a tax that consumers in some countries still pay on these goods. That would benefit people living in rural areas of developing countries especially, as it is in such areas that many renewable-energy technologies are making, and are likely to make, their greatest contribution. The economic benefits of activities enabled by electricity — such as comfort, communication, education and entertainment — are enormous and have been estimated to be perhaps double those associated with the more traditional measure: cost savings from displacing kerosene for lighting.[1] To the extent that reducing import tariffs also reduces the costs of grid-connected technologies, it would increase the affordability of these technologies in the portfolio of generating options available to electric utilities.

Manufacturers located in OECD countries would benefit from increased trade in renewable-energy technologies and components, to be sure. But so would a growing number of companies based in developing countries that have emerged in recent years. These include companies ranging in size from small-scale merchants of PV-based systems to local affiliates of the large wind-turbine manufacturers. Already, Brazil, China, India and South Africa are emerging as centres for sales of renewable-energy technologies in their respective regions. Many other countries could become producers of these technologies, either through development of their own, independent companies, or in alliance with established companies. Indeed, the fact that a number of the components of renewable-energy-based systems, such as lead-acid batteries and wind-turbine blades and towers, are bulky to transport works to the advantage of local or regional producers, all other considerations being equal.

The elimination of tariffs would also help to level the playing field between some aid-financed goods and goods imported through normal market transactions. Goods associated with aid projects, for example, tend to receive waivers of import duties. Such waivers help customers in the short run but undermine the emergence of a commercially viable local industry. Other reforms may be needed of non-tariff barriers, but these have not been examined in the current draft.

For the maximum benefits of trade liberalisation in renewable-energy technologies to be realised, additional reforms may be required in countries' domestic policies, especially those affecting the electricity sector, and rural electrification in particular. Studies of experiences with renewable energy carried out by other investigators suggest that several factors are important: *(i)* creating a stable investment climate for investors in energy projects; *(ii)* allowing competition in choices among different electric power options; *(iii)* making the high cost of extending electricity transmission lines into rural areas more transparent, and reducing or ending cross-subsidies for their construction; and *(iv)* developing innovative ways to finance small-scale projects. Environmental policies are also crucial, especially in the markets for competing grid-connected technologies. Basically, the more stringent are a country's limits on emissions of pollutants, the better chance renewable energy has to compete with dirtier fuels.

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1 Cabraal and Fitzgerald (2002), p. 2.

Introduction

Various countries have proposed including renewable-energy technologies among goods for consideration in a list, or lists, of environmental goods, as part of the Doha ¶ 31(iii) negotiations. Both the APEC and the OECD lists referred to several renewable-energy technologies, as have Canada, the European Commission, Japan, Korea, New Zealand, Switzerland, and the United States, in their lists and Qatar in the context of hybrid energy systems that combine renewable energy sources with natural gas.[2] Some analysts have even suggested that renewables should be regarded as a special category of environmentally preferable products (EPPs), inasmuch as they are seen to be preferable to energy derived from fossil fuels.

When contemplating whether to liberalise trade in an environmental good, it is helpful to know how high are the remaining barriers, and how the costs and benefits of reducing those barriers would be distributed. This study attempts to explore these issues by: *(i)* identifying a positive list of renewable energy and associated technologies of interest to both developed and developing countries; *(ii)* among those, identifying goods of special interest to developing countries; and *(iii)* exploring the effects of liberalisation for selected countries and products.

The environmental, economic and development cases for renewables

The International Energy Agency (IEA, 2004a) defines renewable energy as "energy that is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources." Renewable energy normally does not include energy derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources.

The idea of tapping in to the enormous amount of energy that arrives freely from the sun, or passes by in the winds, or bubbles up from the depths of the earth, has attracted scientists and engineers for centuries. The economic development of many economies and regions began with such efforts, notably through the exploitation of wind power (The Netherlands in the 18th century) and hydroelectric power (Austria, Norway, Switzerland and others in the 20th century). When in the 1970s alarm was raised over future supplies of energy, policy makers also began to envisage renewable energy (and in some countries nuclear power) eventually replacing fossil fuels as cheap supplies of the latter ran out. Fear of energy shortages waned in the 1980s but was succeeded by a new argument for renewable energy: the need to develop low-carbon alternatives to the coal, oil and natural gas on which the world currently depends.

With world demand for energy again growing apace, driven more and more by economic expansion in newly industrialising countries, international interest in facilitating the spread of renewable energy technologies across the globe has never been higher. The IEA's latest *World Energy Outlook* (IEA, 2004b), in its "Reference Scenario", projects that, in the absence of new government policies or accelerated deployment of new technology, world primary energy demand is set to rise by almost 60% between 2004 and 2030. Some 85% of that increase would be in the form of carbon-emitting fossil fuels. Two-thirds of the new demand is expected to come from the developing world, especially China and India.

The environmental case for renewable energy is slightly different for biomass fuels and geothermal energy than for technologies that transform falling water, wind or sunlight into useful heat, mechanical power or electricity. Biofuels may emit some pollutants when combusted, but they generally burn cleaner

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2 A complete listing, as of November 2005, can be obtained in document TN/TE/W/63, available, as are other WTO official documents, from http://docsonline.wto.org/gen_search.asp?searchmode=simple.

than corresponding fuels used in similar applications. (The exception is biomass burned in open hearths.) Moreover, their net contribution to CO_2 emissions is much lower or zero. The environmental case for other renewable energy technologies stresses the lack or absence of air-pollutant emissions during their normal operation. Table 1 shows that, when monetised, the external costs — i.e., those costs imposed, but not borne, by producers or consumers of a good or service — associated with solar photovoltaic plants and wind turbines are very low compared with those associated with electricity production from fossil fuels.

Table 1. Range of generating costs and external costs for different electric generating technologies as of the late 1990s[1]

(Euro cents per kWh)

Type of power plant	*Generating costs*	*External costs*
Coal or lignite	3.2-5.0	1.8-15.0
Fuel oil	4.9-5.2	2.9-10.9
Natural gas	2.6-3.5	0.5-3.5
Nuclear energy	3.4-5.9	0.24-0.7
Biomass	3.4-4.3	0.24-5.2
Solar photovoltaic	51.2-85.3	0.14-0.33
Wind turbine	6.7-7.2	0.05-0.26

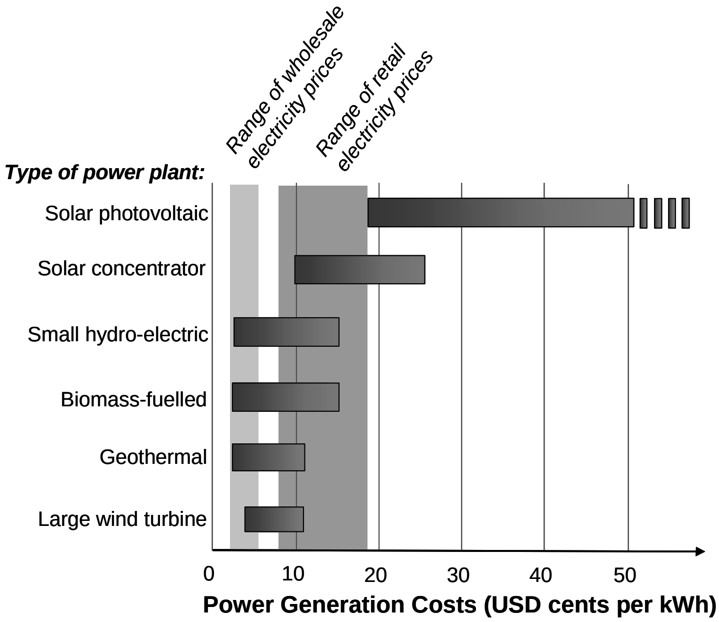
1. Caution should be used when interpreting this table. Environmental externalities associated with various energy technologies are highly dependent on the severity and nature of site-specific environmental effects (e.g., air pollution). It is also difficult to estimate externality values for greenhouse gas emissions with any degree of accuracy.

Data source: Nuclear Energy Agency, *Nuclear Electricity Generation: What Are the External Costs?*, OECD Publications, Paris, 2003, p. 37, based on data in European Commission DGXII, *ExternE: Externalites of Energy*, Vol. 10, *National Implementation*, EC, Brussels, Belgium, 1999.

Often not counted in estimates of external costs associated with different electric generating technologies are those relating to high-voltage transmission lines. The corridors created for these lines can create new points of access to forested areas and contribute to ecosystem fragmentation (Kaufman, 1999). A particular advantage of small-scale renewable-energy based electricity systems for areas of countries not currently connected to electricity grids is that they avoid the need for power transmission lines, and reduce the amount of fuel transported to remote areas. These attributes can be particularly important for preserving protected forests and other vulnerable ecosystems.

The economic case for renewables is strongest where such environmental externalities are taken into account, or where the potential customers are dispersed and do not already have access to an electricity grid. Over the past two decades, the costs of generating electricity from renewable energy has dropped dramatically. Photovoltaic cells, for example, have experienced a price reduction of approximately 20% with every doubling of their cumulative production (Luther, 2004). Depending on the quality of the resource (geothermal heat, wind velocity and consistency, insolation), the costs of generating electricity from renewable energy can be competitive with the price of electricity paid by final consumers (favouring dispersed, small-scale units) or by electric utilities for bulk power (Figure 1). Costs of most of the newer technologies are expected to continue to fall as new materials are discovered and economies of scale are exploited.

Figure 1. Cost competitiveness of selected renewable power technologies as of the early 2000s.



Source: Adapted from NET Ltd. Switzerland, in *Renewables for Power Generation: Status and Prospects*, 2003 edition, International Energy Agency, OECD Publications, Paris, p. 20.

The developmental case for renewables derives from the health benefits enabled by switching to cleaner fuels, and from the activities made possible by bringing electricity to households and small, rural businesses that previously did not have access to that form of energy. Currently, around 1.6 billion people in the world have no access to electricity and, in absence of new policies, 1.4 billion will still lack it in 2030 (IEA, 2004b). Numerous socio-economic impact studies have demonstrated the enormous difference that electrification can make for economic development. One, carried out in the Philippines, found that, controlling for all other factors, electrification of rural households in that country resulted on average in 1.82 additional years of education (because better lighting allows for more study time), 33 extra hours a month of leisure time, and USD 36 more income each month from additional business hours (in households with a business).[3] Reducing the usage of kerosene lanterns and paraffin candles for lighting also alleviates a fire hazard and, in the case of kerosene, lessens the risk of accidental poisoning (Kaufman, 1999).

International trade and tariffs

Trade in technologies used in harnessing renewable energy is clearly of environmental signifi-cance. It is also believed to be growing at a fast pace. Because the Harmonized Commodity Coding and Classification System (HS) does not have separate 6-digit codes for all the technologies used to harness renewable energy, however, statistics on world trade in renewables are imprecise.[4]

3 A. Domdom, V. Abiad, D. Barnes and H. Peskin, "Benefit estimates of rural electrification in the Philippines", presentation to the Joint Donors' Meetings for Trust Funded Energy Programs at the World Bank (Washington, D.C., 7-8 May 2001) http://www.worldbank.org/html/fpd/esmap/pdfs/phil_elec.pdf

4 The International Energy Agency (IEA) has previously pointed to potential problems caused by the lack of stand-alone customs codes for integrated plants, like geothermal electric power plants.

Trade in renewables falls into two categories: trade in renewable energy products (such as liquid and solid fuels made from biomass), and trade in goods used in the harnessing of renewable energy, such as arrays of photoelectric cells, wind-driven water pumps, and hydraulic turbines and water wheels. Annex Table 1 lists some of the main HS (2002) sub-headings and codes under which renewables are classified for the purposes of import duties and statistics.[5] A few HS codes are specific, such as for fuel wood (HS 4401.10), wood charcoal (HS 4401.10), hydraulic turbines (HS 84.10) and wind-powered generating sets (HS 4401.10). Others are less specific. The code for photosensitive semiconductor devices (HS 8541.40), for example, covers not only photovoltaic cells but also light-emitting diodes (LEDs) and photo-sensitive transistors. None of these limitations was addressed in the latest revision of the HS, scheduled to go into effect by 2007.[6]

A number of other goods are not so readily identified in the HS as "renewable-energy technologies" but are nonetheless essential to systems built around them (Annex Table 2). Most of these, such as other engines and motors (HS 84.12) and mechanical stokers (HS 8416.30), have multiple applications. But a few, particularly those that either run off of direct current (DC) electricity, or are used to regulate it or convert it to alternating current (AC), could easily be distinguished in national tariff schedules at the 8- or 10-digit level.

Because of the limitations of the HS, it is not possible to give a global estimate of the value of trade in renewable energy and related technologies. But, judging from Annex Table 3, it could well be in the neighbourhood of USD 4 billion a year. OECD countries clearly dominate exports of high-tech renewable-energy technologies, but in renewable-energy fuels, and in such relatively low-tech devices as solar water heaters, developing countries and countries in transition are major players, both as users and exporters. This finding is in keeping with an earlier analysis by UNCTAD (2003); their calculations estimate that, whereas developing countries are net importers of environmental goods that are capital goods, exports and imports in 2002 were roughly in balance for renewable energy products.

Annex Table 3 points to large differences in the volume of world trade in renewables, and the share of non-OECD countries in that trade. In the cases of ***fuel wood*** and ***wood charcoal***, more than 40% of exports originate from outside the OECD countries. Another market in which there is considerable developing-country participation is ***solar water heaters***, which are covered by HS 8419.19.

World trade in small ***hydraulic turbines*** (less than 10 MW output) — the kind used in so-called "micro" and "mini" hydroelectric plants, such as run-of-river plants — is, by comparison, tiny: less than USD 30 million in each of the two categories (HS 8410.11 and 8410.12) in 2003. Trade in hydraulic turbines of greater than 10 MW capacity (HS 8410.13) is larger, but still small (USD 47 million). In all three categories, OECD countries account for the bulk of export sales. The market for hydraulic turbines is heavily influenced by government procurement, which may account for the relatively small share of imports in total global sales. Export sales of ***parts for hydraulic turbines***, by contrast, are four times that of turbines, reaching USD 436 million in 2003. Some 80% of exports are from OECD countries.

Currently, international trade in ***wind-powered electric generating sets*** (HS 8502.31) is highly concentrated, with European companies accounting for more than 70% of global exports (EWEA, 2004). But several developing and transition countries are starting to emerge as important suppliers of components. There is much less known about world trade in ***photovoltaic (solar) cells***, whether assembled into modules or panels or not (HS 8541.40 ex), since statistics as the 6-digit HS level include other

[5] Because ethanol is considered an agricultural product for the purpose of the WTO negotiations, they are not discussed in this paper.

[6] Besides these codes are those for components that go into renewable-energy plant, such as electrical wiring and steel for support structures, which are not unique to renewable energy.

photosensitive semiconductor devices, and light-emitting diodes (LEDs), which for the moment have bigger markets. Developing-country manufacturers of PV cells and modules include Brazil, China, India, the Philippines and Saudi Arabia.

Regarding import tariffs, preliminary analysis suggests that applied tariffs on wood and charcoal exceeding 25% are fairly common among developing countries, even those that use a lot of wood or charcoal for domestic cooking. Tariffs on hydraulic turbines, parts for hydraulic turbines, wind-powered generating sets and solar cells exceed 15% in 10 or fewer countries in each case. Most striking are the tariffs on solar water heaters, which surpass 25% in a number of countries — including those whose sunny climates or dispersed rural populations would seem to be conducive to deployment of the technology.

Assessing the effects of liberalising trade in renewable energy and related technologies

This section examines the markets for, and the potential effects of, liberalising trade in, a selection of representative products. The products selected — charcoal, solar photovoltaic cells and modules, and wind turbines and pumps — cover three of the fastest-growing segments of the renewable-energy market, and several of the energy sources. For each product, an attempt is made to analyse the potential environmental and developmental effects of liberalisation, as well as economic and trade-related benefits that can be easily identified. Special attention is given to assessing the developmental benefits for the most-vulnerable populations. Each sub-section then identifies possible complementary changes in trade-related or environmental policies that would help ensure the maximum realisation of trade, environmental, and development benefits.

Wood charcoal

The fuel and related technology

Charcoal is a black, porous material, containing 85% to 98% carbon, derived from wood or woody biomass. Although its first uses predate history, its controlled production can be traced back at least 3500 years. As the FAO wrote in 1987, and it remains true, "[t]hroughout the world wood is turned into charcoal by a surprising variety of systems." Traditional charcoal-making involves heating biomass in an earthen mound to drive off moisture and some of the wood's volatile matter. It is inexpensive, but yields are poor, typically 10% on a mass-balance basis, and large amounts of ground-level air pollution are released in the process. Improved traditional methods use small-scale steel or brick kilns, which provide more-consistent results and are less labour-intensive than the traditional method. Yields can be as high as 20% but are more typically around 15% (Stassen, 2002).

Industrial methods seek to precisely control variables such as temperature, oxygen supply and pressure. Various technologies are used, involving batch-wise operated brick or metal kilns or continuously operated retorts. The highest efficiencies in commercial use (1 kg of charcoal from 3-4 kg of wood) are obtained by heating pre-dried wood in a ceramic brick-lined carbonisation furnace at peak temperatures of around 900°C. The tars and gases produced as the wood heats up are separately combusted and the flue gas is then used to heat the carbonization furnace and to pre-dry the wood (Stassen, 2002). An alternative process, developed at the University of Hawaii in the mid-1990s, obtains high yields (45%, or a thermal efficiency of about 68%) and fast reaction times (hours rather than days) by operating the reactor at elevated pressures in a stagnant gaseous environment (Antal *et al.*, 1996).

Charcoal burns cleaner than wood and dried biomass, produces higher temperatures, and is cheaper to transport and store. For these reasons, interest in charcoal as a fuel is reviving. A recent study, led by researchers at the University of California, Berkeley, and the Harvard School of Public Health (Bailis *et al.*, 2005), suggests that if the large number of households in developing countries that cook and heat their homes with raw biomass were to switch to charcoal, as many as three million premature deaths from respiratory illness due to indoor pollution would be averted, depending on how quickly the transition is made.

Charcoal can also be substituted for coal, a fossil fuel, in industrial and electric power-plant applications. Its energy density, approximately 30 000 kilojoules per kilogramme, is around that of bituminous coal, and its ash and sulphur content is typically equivalent or lower (Arcate, 1998). Because it can be ground to a fine powder, it can be used in many existing boilers designed for pulverised coal. (By contrast, co-firing biomass in pulverised-coal boilers requires investing in a separate biomass feed system.) That attribute creates the potential for quickly and rapidly increasing the share of biomass — the production of which on a life-cycle basis contributes much less to net emissions of CO_2 than coal — in the production of electricity. Charcoal can also be used in cement kilns, but it is generally more expensive than the low-grade fuels, such as petroleum coke, currently preferred by the industry.

Production and trade

Charcoal is produced the world over, often in association with commercial logging, but outside the OECD region and Russia much of its production occurs on a small scale, typically involving no more than covering a stack of burning wood with dirt and leaving it to smoulder for a week. Statistics on global charcoal production are therefore highly approximate. According to various sources (e.g., World Energy Council, 2001; Karekezi *et al.*, 2004), the leading charcoal-producing countries are China, India, Brazil and the countries of tropical Africa (particularly Sudan, Kenya and Cote d'Ivoire). Whereas charcoal consumption is expected to grow moderately in Latin America and East Asia, on recent trends it could grow by 4 or 5 percent a year in South Asia and Africa, leading to more than a doubling of its use in these regions over the next 15 years (Table 2).

Table 2. Estimated and projected charcoal consumption in several world regions

(Millions of tonnes of oil equivalent)

Region	1995	2005[1]	2020[2]	Annual rate of growth
Latin America	6.4	6.8	7.2	0.4%
East Asia	5.6	7.0	9.2	1.9%
South Asia	3.5	6.0	11.1	4.2%
Africa	6.8	13.5	30.8	5.6%

1. Interpolation of the OECD Secretariat between the 1995 estimates and projections for 2010.
2. Projected.
Source: Karekezi, *et al.* (2004) based on Intrenational Energy Agency, *World Energy Outlook, 1998*, OECD Publications, Paris.

Only a small proportion of charcoal production is traded internationally. About 40% of charcoal exports, valued at USD 250 million, originate in OECD countries. Four of the leading exporters of wood charcoal in 2003 were developing countries: China, Argentina, South Africa and Malaysia. Most charcoal entering world trade is used as a fuel or as an input to the production of steel, copper, zinc and certain precious metals. Some is further processed into activated charcoal, a highly porous material used in filtering out impurities from liquids and gases.

Most OECD countries apply a zero tariff on wood charcoal. By contrast, applied import tariffs on wood charcoal exceed 20% in many African countries and reach 100% in Libya and the Seychelles. Although trade in charcoal has never comprised a large share of total production and consumption, it is striking that some of the highest tariffs are found in precisely the region that is the most dependent on charcoal as a fuel. In 2000, nearly 470 million tonnes of wood were consumed in homes in sub-Saharan Africa in the form of firewood or charcoal, the highest per capita rate of consumption of any world region.

Potential implications of liberalising trade in wood charcoal

The trade and environmental effects of liberalising trade in wood and charcoal would depend on a wide number of variables. Most countries have the potential to produce charcoal, and many could be net exporters of the substance. For the supply of charcoal to be sustainable, however, close attention has to be paid to the management of the feedstock resource. Some charcoal is already made from waste material generated by the forest industry and from agriculture, such as nut shells and husks, and sugar-cane leaves. Additional charcoal could be produced from biomass obtained from the prunings of trees in towns and cities, and from other "clean" wood.[7] However, any substantial increase in charcoal production would have to come from harvesting fast-growing trees or other suitable energy crops, including shrubs and switchgrass.

Increasing the efficiency of charcoal production would also help to minimise pressures on forest resources, and enable economies of scale to be realised. Modern, high-yield systems can produce three times as much charcoal from a given amount of feedstock as traditional charcoal-making kilns, with far lower emissions. The FAO reports that improved charcoal-making facilities are now being built not only in OECD countries but also in countries like China, Ghana and South Africa (Stassen, 2002). A factory for producing charcoal from municipal waste wood is under construction in Singapore.

Any development in the trade that resulted in greater volumes of charcoal becoming available at a lower cost would mean tremendous benefits for consumers in developing countries in particular. More households could switch from using raw biomass, and thereby substantially reduce their exposure to air pollutants. If that charcoal were used in improved cooking stoves, the energy-efficiency of cooking would increase dramatically, further reducing the time required for meal preparation and therefore exposure to pollutants (Tothova, 2005).

Benefits derived from using charcoal for the generation of steam heat, particularly in electric power plants, would likely be realised over the longer term, and would depend critically on the relative prices of charcoal and coal, and policies constraining emissions of greenhouse gases. Currently, most of the world's coal-fired industrial and power plants are found in OECD countries, and in China, India, Indonesia, Russia and South Africa. Many, if not most, of these installations are centred around coal fields, from which coal can be procured at costs ranging from around USD 30 to USD 50 a tonne (IEA, 2005). By comparison, imported charcoal, even if free of import duties, currently costs USD 100 a tonne, or more.[8] However, where coal-fired plants have been built near ports, and are dependent on imported fuel, charcoal — either domestically sourced or imported — could become an economically viable fuel supplement for some plants.

Complementary policies

As mentioned above, any change in policy that would encourage greater production and use of charcoal is often greeted with nervousness among the environmental community. With reason: besides the prospect of denuded forests, scenarios that envisage large shifts to charcoal and no improvements in harvesting and production suggest that associated greenhouse gas emissions could reach 15 billion tonnes

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7 Arcate (1998) defines clean wood as stumps, branches over 10 centimetres in diameter, and untreated and unpainted pallets and construction lumber that is free of metal, concrete and other non-woody material.

8 This is an indicative price.

of carbon by 2050 (Bailis *et al.*, 2005). But with the correct incentives at each stage, from biomass production through end-use, negative consequences need not be inevitable. As expressed by Girard (2002: 31):

> The sustainable production and use of charcoal through proper management and planning of supply sources, together with rational trade and marketing infrastructures and efficient use, can also have a significant positive impact by helping to conserve resources, reducing migration from rural or forested areas and improving people's incomes. However, the necessary interventions for long-term solutions are not easy to implement, especially for poor tropical countries that lack the necessary financial resources, institutional capacity and skilled personnel.

The alternative in the short and medium term is not necessarily to increase the availability of kerosene or liquefied petroleum gas (LPG) to households. A study in Dar-es-Salaam, Tanzania, found that charcoal used in energy-efficient stoves was the cheapest fuel per unit of energy delivered (Foster, 2000). With free-market prices for kerosene now more than 60% higher than in the late 1990s, the relative cost of charcoal cooking is likely to look even more attractive. Nonetheless, over the last two decades many governments, concerned about the potential threat of charcoal to forest resources and encouraged by multilateral lending agencies (see, e.g., van der Plas, 1995), have tried to encourage LPG and kerosene use, in some cases by subsidising these fuels or furnishing households with new equipment (Girard, 2002). In Africa these programmes have not been as successful as had been originally hoped, in part because, as Matly (2000) observes, people who move to cities do not always readily adopt urban habits. Moreover, fuel-substitution programmes and policies to stamp out charcoal production have at times backfired, creating unemployment in forest areas. This unemployment in turn increased the rate of rural-urban migration, thereby accentuating the demand for fuelwood and especially for charcoal (Girard, 2002).

Lowering barriers to trade in charcoal could help create more stable markets, which in turn would help encourage investment in newer and more-efficient charcoal-making technologies. But obtaining a net positive outcome from liberalising trade in charcoal would depend on the degree to which the following occurred:

- The management of forests and other lands on which plant species suitable to charcoal production are grown is strengthened, particularly in developing countries, so that over-harvesting is avoided. Forest-management certification schemes are already playing a small role in this regard (Box 1).

- Programmes to help the spread of improved charcoal-making techniques, including training for operators, are stepped up.

- Studies are undertaken to identify bottlenecks that may arise in the distribution chain.

- Information is provided to households in developing countries on the time they could save, and the improvement in their health they would see, from using charcoal in efficient cooking stoves.

The social implications of encouraging greater commercial production of charcoal in developing countries, especially if it is at the expense of small-scale production by the informal sector, would not be trivial. The professionalisation of the sector would create job opportunities for people working for the charcoal makers and distributors, but would eliminate an income source for some small, local suppliers. In order to avoid rural unemployment and rural-urban migration, complementary programmes to help identify new income sources would be vital.

Box 1. Producing charcoal from a sustainably managed forest

Currently there are less than a handful of enterprises in the world that sell hardwood charcoal from forests certified to FSC (Forest Stewardship Council) standards. One of them is Noram de Mexico, S.A., which produces natural charcoal from 100% scrub oak hardwood. Its source for raw materials, the pine-oak forests of the Sierra Madre, are home to black bear, puma, Mexican wolf, the thick-billed parrot, the eared trogon and the imperial woodpecker, and are internationally recognized as areas of high endemism and biodiversity.

About half of Noram's raw materials, such as oak branches gathered from nearby pine-oak forests, are purchased from local indigenous communities (*ejidos*). Noram supports these communities by providing training in such practices as pruning, fire prevention and the protection of reforested areas and biodiversity corridors. It is also increasing the benefits *ejidos* receive from their sustainable forestry practices by promoting forest conservation projects in co-ordination with the Consejo Civil Mexicano de Silvicultura Sostenible. Locally, Noram's charcoal is sold through leading Mexican supermarket chains; Mexicans are estimated to consume 200 000 tonnes of charcoal annually — as much as consumed by the entire EU. The company has been exporting charcoal to Europe since 1996 and recently began selling its product to customers in the United States.

In 2000 Noram won first prize at the World Resource Institute's (WRI's) New Ventures Investor Forum, an annual WRI gathering which attracts hundreds of venture capitalists, investment bankers, and entrepreneurs from across Latin America. Part of Noram's equity is held by two venture capital firms, Environmental Enterprises, a Washington-based firm established with support from major U.S. foundations, and EcoEnterprises Fund, a firm recently launched in San Jose, Costa Rica by The Nature Conservancy and the Multilateral Investment Fund of the Inter-American Development Bank. These firms have also provided long-term loans to Noram. In addition, the Andean Development Corporation (Corporación Andina de Fomento), a Latin American regional development bank, has provided the company with a 7-year, USD 400 000 working capital loan from its Human Development Fund (Fondo de Desarollo Humano).

Sources: Abstracted from http://www.ecoenterprisesfund.com/Portfolio/deal%20sheets/noram.htm, http://www.new-ventures.org/opportunities.investors.noramnv.html and http://www.new-ventures.org/aboutus.successes.norampressrelease.html

Solar photovoltaic cells, modules and systems

The technology

Energy from the sun can be harnessed in several ways to produce electricity. Solar photovoltaic (PV) cells work by converting the energy from photons from sunlight into direct-current electricity. Solar PV cells are simple devices to use, but because they are currently made with semiconducting materials, either in thin wafers (cells) of pure crystalline silicon, or in thin strips of amorphous silicon, their manufacturing is complex and relatively costly. Individual PV cells are fragile and produce a maximum output of only 2 watts, so they are normally soldered together in series, usually of 36 or 72 cells, and then hermetically sealed in an encapsulated assembly. These assemblies, called modules, sandwich the cells between a rigid, transparent top surface (usually of glass) and an insulating backface. A typical weather-resistant module (also sometimes called a solar panel) can provide between 20 and 30 years of safe, reliable service.

There are only a few centralised, on-grid solar PV installations in the world, and most are heavily supported, through direct subsidies and regulated prices. The largest solar-electric plant in the world is the 10-MW Bavaria Solarpark, comprised of 57 600 photovoltaic panels. Most applications of solar PV cells are much smaller in scale, supplying electric power for a device such as a water pump, or to a home or a village.

Solar water-pumping systems are particularly well suited to rural areas. They usually consist of two to four PV modules; a variable-voltage, direct-current electric pump; and associated piping and storage tanks. Apart from pumps, other common dedicated, single-use applications of PV systems include supplying electric current for rural telecommunications systems, navigation beacons, and isolated data monitoring and recording systems, and providing cathodic protection for pipelines.

Grid-connected distributed PV systems are intended to supplement electric power supplied by mains and, in some cases, to feed electricity back to the grid. These kinds of installations exist mainly in OECD countries, especially Germany and Japan. Most of the off-grid, domestic applications of solar energy are in rural areas, increasingly of developing countries, where some 400 000 are already in operation. A basic household solar module will typically comprise a roof-mounted 15-Watt to 150-Watt solar array, a 20 to 100 ampre-hour solar (lead-acid) battery, a charge controller (for optimising the charging and discharging of the battery), several low voltage and low-wattage lamps (Box 2), and accessories such as connecting cables, mounting brackets, and fasteners. A larger system will also include an inverter to convert 12-volt direct current into standard 110 or 220 volt alternating current, for operating radios or other household appliances.

Box 2. Reducing costs with light-emitting diodes

In order to reduce the required number of solar cells, most household solar PV systems are designed to use low-wattage electric lamps for lighting. Traditionally that has meant fluorescent lamps, which need less than one-third the energy per lumen of incandescent filament lamps (i.e., the classic light bulb). White-light-emitting diodes (WLEDs) require even less energy per lumen than fluorescent lamps (and only 5% of incandescent lamps), but they are expensive and so far have been used primarily in specialty applications. Nepal's Centre for Renewable Energy (CRE), however, has shown that when hooked up to small solar-based power sources, WLEDs can be cost-effective.

With financial support provided by the Swedish International Development Co-operation Agency (Sida), under the framework of the "Renewable Energy Technologies in Asia — A Regional Research and Dissemination Programme" project, the CRE has developed a lighting system based on a single solar PV cell (around 2-3 Watt-peak) and two WLED-based lamps. Each lamp is made up of three tiny WLEDs, which together consume only 0.3 Watt of electrical power but produce sufficient focussed light (275 lux[1] at a distance of 30 cm from the source) to replace a traditional kerosene lamp. An economic analysis conducted by the CRE found that the cost of the system is roughly equal to what a typical rural household spends on kerosene (for two lamps burning around 4-5 hours daily) and dry-cell batteries (to operate a radio and torch light) over a period of slightly more than two years. Annual operating costs, mainly associated with the replacement of rechargeable batteries once every two years, are minimal: about Rs. 300 (USD 4). A survey of 43 users revealed a high degree of customer satisfaction with the system.

WLEDs are classified under the same HS sub-heading (8541.40) as solar cells.

1. Lux is the metric unit for measuring the illuminance of a surface; one lux is equal to one lumen per square metre.
Sources: Sharma *et al.* (2005); Kumar *et al.* (2005); and the Light Up the World Foundation http://www.lutw.org/illum_benefits.html.

Production and trade in PV cells and modules

According to industry sources[9], global production of solar PV cells was around 1200 MW in 2004, an increase of almost 60% over the previous year. Over the past 15 years, growth has averaged around 25% a year. Solarbuzz.com predicts that industry annual turnover will grow from USD 6.5 billion in 2004 to USD 18.5 billion by 2010.

Manufacturing of solar PV cells is dominated by five companies: Sharp Electronics Corporation, Kyocera Solar, BP Solar, Shell Solar Industries, and Sanyo Electric Company. Sharp, Kyocera and Sanyo

9 *Photon International* (http://www.photon-magazine.com/) reports production of 1256 MW, and Solarbuzz (http://www.solarbuzz.com/) reports 1146 MW, in 2004.

produce mainly in Japan; Shell's PV-cell manufacturing facilities are in Germany and the United States; and BP Solar has plants in Australia, India, Spain and the United States. Although Japan still accounts for half the world's solar-cell production and exports, followed by the United States and the EU, production from the rest of the world is increasing rapidly, more than doubling in 2004, to 171 MW. A private company in Saudi Arabia, Al-Afandi Solar Wafers and Cells (part of the much larger Al-Afandi conglomerate), has recently begun manufacturing multicrystalline solar cells for clients in Germany at its factory in Jeddah.[10]

The manufacturing of solar modules is more geographically distributed. Some companies, like Total Energie Southern Africa (TENESA) are local affiliates of solar majors.[11] Others are joint ventures between one of the solar majors and a local energy or electronics company. One of the first was Tata BP Solar, set up in India as a joint venture between Tata Power and BP Solar in 1989. It is now India's leading supplier of solar-energy technologies, and its 38-MW solar module manufacturing facility in Bangalore is one of the largest of its kind in the world. More than half of its total sales derive from exports, mainly to Europe and North America. Manufacturers have also established subsidiaries in developing countries for marketing cells, modules and systems. In most cases, these subsidiaries are staffed by local sales agents and engineers.

Elsewhere, there are a growing number of independent suppliers and installers of solar PV systems, especially for off-grid use. Energy Source Guides (energy.sourceguides.com) lists around 35 manufacturers of solar PV cells or modules, and 115 suppliers of solar electric power systems, in India. One of them, Ammini Solar, based around Trivandrum, has expanded from a 3-person firm in 1993 to become the country's largest producer of solar lighting systems. Kenya has at least nine small and medium-sized companies marketing PV systems for household or communal use.[12] These systems are based largely on imported components, and are assembled and serviced locally. According to the Solar Electric Light Fund, since the mid-1980s over 20 000 household solar PV systems have been installed in Kenya by independent businesses operating on a strictly cash basis.[13]

In Asia, a Regional Research and Dissemination Programme, supported by the Swedish International Development Co-operation Agency (Sida) and co-ordinated by the Asian Institute of Technology (AIT), has been sponsoring adaptive research on PV-system components under the Renewable Energy Technologies in Asia programme. Locally designed components were first tested in laboratories and then installed in the field. Today, charge controllers, ballasts for fluorescent lamps, converters and inverters are being manufactured in Bangladesh, Cambodia and Vietnam (Box 3). Benefits include improvements in after-sales service and in the availability of spare parts (Kumar *et al.*, 2005).

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10 http://www.photon-magazine.com/news/news_2004-10_%20af%20sn%20Cell%20Factory%20in%20Saudi%20Arabia.htm

11 http://www.total-energie.fr/Filiales/Tenesa/

12 See http://energy.sourceguides.com/businesses/byGeo/byC/Kenya/Kenya.shtml and http://www.solarbuzz.com/CompanyListings/Kenya.htm

13 http://www.self.org/shs_role.asp

Box 3. Developing solar PV components in Bangladesh, Cambodia and Vietnam

Under the RETs in Asia programme, demonstration systems were built to increase awareness of solar PV technology, and local people were trained in the operation, maintenance and management of these systems, with the aim of improving after-sales service. Results from the programme were disseminated through workshops and seminars, and are summarised below:

Bangladesh: As of June 2005, about 100 000 solar lamps (using locally designed and manufactured ballasts), 30 000 charge controllers and 6 000 DC-to-DC converters had been developed and were being used in the field. Costs of production are up to 50% below the price of imported components, resulting in overall savings of 10% on the total cost of a solar household system.

Cambodia: The programme resulted in the development of a type of charge controller, 40 of which have been installed in street lights on a rural bridge (as part of a demonstration project funded by the Government). In their first eighteen months of operation, no major problems were reported.

Vietnam: Four different prototypes were developed, of which three (charge controller, ballast for fluorescent lamp and inverter) have been commercialised. The programme also developed a direct current (DC) energy-saving lamp.

Source: Kumar *et al.* (2005).

Potential implications of liberalising trade in PV cells

Liberalisation of trade in solar-photovoltaic technologies and related components would benefit several groups of countries. Consumers everywhere would benefit from lowered costs of solar-generated electricity, which requires no fuel, nor fuel-related infrastructure, and is emission-free. As PV cells account for more than half of the cost of an installed residential solar-electricity system, reducing tariffs on these would have a significant effect on overall costs. MFN tariffs are currently 20% in several countries with a high solar-energy potential: Cambodia, the Solomon Islands, Djibouti, Libya, Maldives, Vanuatu and Ethiopia. They are 15% in India, Nepal, Nigeria, Oman, Rwanda, Seychelles, the Syrian Arab Republic and Yemen. Eliminating import duties entirely would thus cut the cost of purchasing PV systems by 7-10%. Eliminating import duties on related components of solar electricity systems, such as storage batteries, charge controllers, compact fluorescent lamps, and inverters, would further reduce costs, making solar-PV systems even more affordable (Box 4).

Box 4. Promoting solar photovoltaic systems in the Sudan

"Sudan's main energy source is biomass, mostly in traditional uses. Electricity constitutes only 2% of the country's energy consumption. The national electricity grid reaches a half million households, less than 10% of the population; major and minor local grids serve another 5%. Consequently, the majority of Sudanese take care of their energy needs themselves. In addition to biomass, liquefied petroleum gas and charcoal are sources of household energy. Wealthier households often invest in diesel generators. …

"Today, the Sudanese government is actively supporting PV policies. The [GEF's] solar PV project has contributed to enhanced awareness of the social and economic potential of PV power and has boosted activities by the National Energy Committee of the National Assembly to enact a Solar Energy Act. In the annual 2004 national development budget, the parliament passed a resolution exempting PV-system components from import duties and the value added tax. The government has further decided to invest in a joint venture with China for a module assembly line. It is expected that the combined effects of tax reduction and local assembly will reduce PV costs by 30–40%."

Source: Abridged from GEF (2004), pp. 4-5 http://www.gefweb.org/Outreach/outreach-PUblications/Renew_Energy_inserts.pdf

The initial beneficiaries from increased sales of PV cells and modules would include the major manufacturers listed above. However, with new manufacturing and assembly plants being built close to final markets, exports from several developing countries could be boosted as well. At the moment, the beneficiaries could include Brazil, China, India, the Philippines, Saudi Arabia and South Africa. Greater local demand would also benefit companies and their employees in numerous developing countries that specialise in the assembly and installation of solar-PV systems for rural areas. Liberalising trade in PV-system components, such as charge controllers and DC-powered electric lamps and home appliances[14], would spread the benefits even further, as many of these devices are manufactured primarily in developing countries.

Eliminating tariffs on PV cells and modules would also enable suppliers to better rationalise their supply chains. Currently, several suppliers have set up warehouses for stockpiling PV modules in strategic locations (e.g., southern Africa and south-east Asia) in countries applying low or zero tariffs on these products. This enables them to meet local orders more quickly and to re-export modules to other countries as needed. In other regions, PV modules are subject to tariffs applied both by the country to which they were initially shipped and then by the countries to which they were re-exported (usually as part of a PV-system). These extra charges ultimately end up increasing the cost of PV-produced electricity. The alternative is to wait for a specific order and to ship to the final customer directly, and at much higher cost.

The environmental effects of liberalising trade in PV technology would depend on the degree to which solar PV systems substitute for other means of producing electricity that would have been used in its place. Solar PV-cell modules normally produce no waste products while in operation. However, the manufacture of the cells does require energy and materials, and it may emit pollutants. Also, the disposal of cells at the module's end of life may have impacts on the environment. Still, most life-cycle studies[15] (World Energy Council, 2004) suggest that lifetime emissions of CO_2 are comparable with those from other renewable-energy technologies — i.e., less than 100 grams per kilowatt-hour — and far less than those from fossil-fuel electricity plants, which can be 10 to 20 times higher.

Complementary policies

The world market for PV modules and systems is currently heavily influenced by government policies. In developed countries, consumption of PV systems for homes and larger installations is often subsidised in the interest of diversifying energy sources and stimulating the marked so that the industry may continue to move down the experience curve, finding new ways to reduce production costs.

A large share of exports of solar PV systems from developed to developing countries are associated with aid projects, some of which are tied — i.e., provided on the condition that the recipient country use the funds to buy goods or services from the donor country — or involve donations in-kind, or directed credit. Equipment imported for small projects funded by charities and other non-governmental organisations often must pay whatever import duties apply, and equipment imported by local commercial enterprises must always pay them. Yet solar modules and related components associated with large projects, especially if they are part of a tied-aid project, often benefit from tariff waivers. Tied aid distorts competition in favour of the exporter whose products are given preference. To the extent that those same exporters benefit from tariff waivers and their competitors do not, the distortion is only accentuated. If there are no tariffs to waive in the first place, the degree of distortion will be less.

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14 DC-powered electric lamps are also used in bicycle headlights and motorised vehicles. And DC-powered refrigerators are used in camping vans. But the main market is in connection in homes powered by PV-systems.

15 Taking into account all processes: energy extraction, plant construction, fuel transportation and refining, and plant operation and maintenance.

Box 5. OECD approaches to supporting the dissemination of solar PV systems

Virtually all OECD countries support research and development on renewable energy sources and the technologies to produce or exploit them. Many of these policies are aimed at increasing the share of renewable energy in grid-based electricity generation, but OECD countries have also encouraged the dissemination of renewable-energy technologies for distributed uses, such as supplying electricity for remote farmsteads or villages, buoys and similar isolated devices, and individual homes.

Many OECD countries, and sub-national governments, provide partial grants, tax credits or rebates to households and community organisations that install small-scale PV power systems. The practice by electric utilities of buying back surplus electricity generated by residential PV systems at the retail price of electricity has also helped stimulate demand. A few countries have established programmes specifically aimed at getting homeowners to install solar thermal water heaters or solar photovoltaic modules on rooftops. Germany's "100 000 Roofs Programme", by the time it ended in July 2003, had stimulated the installation of 55 000 solar PV rooftop units with a total capacity of 261 MW. A similar programme in Japan, also established in 1994, led to 162,525 residential PV systems being installed by 2003.

An important feature of several of the programmes is that the incentives for the purchase of PV systems declined over time. Japan's programme, for example, initially covered 50% of the costs of installing PV modules on roofs. As the cost of solar cells fell with cumulative production, however, the subsidy rate was reduced to one-third and then to about 10% of the cost. Despite the reduced subsidy, the number of new units installed each year continues to rise.

Other government policies have also influenced consumer demand for residential PV systems, and for renewable-energy-based electricity in general, through the regulation of air pollutant emissions and ambient air quality. All OECD countries have progressively tightened rules on emissions of air pollutants over the last thirty years, and some have also started to institute limits on total emissions of carbon dioxide, a product of combustion. Such regulations raise the cost or otherwise constrain the building of new fossil-fuelled power stations, making zero-emission electricity generating sources, like solar PV systems and wind turbines, more financially viable.

Sources: IEA (2004c); International Energy Agency, "Global Renewable Energy Policies and Measures Database": http://renewables.iea.org; New Energy Foundation, http://www.nef.or.jp/

Of those aid-related projects that are not tied, most involving bilateral or multilateral aid also benefit from tariff waivers.[16] Although the market distortions caused by these projects are less than for tied-aid projects, especially if the components of the systems are purchased through competitive bidding, if carried out on too large a scale and for too long they risk creating expectations of further donor-giveaways and driving away domestic firms who might otherwise develop a robust renewables market on their own.[17] For that reason, multilateral agencies, such as the International Finance Corporation (IFC), are more and more directing their efforts at accelerating the commercialisation and financial viability of PV-based energy services in developing countries, rather than simply exporting turn-key projects (Box 6).

16 In China during the 1980s and 1990s, for example, applications to reduce or exempt customs duty on renewable-energy technologies and related components imported with international assistance were commonplace, so that the actual duties paid on these goods were very low (NREL, 2004). More generally, the development agencies of some OECD countries include in their assistance agreements special provisions to ensure an exemption from customs duties or other taxes in the recipient country. As of 2003, for example, the United States had 77 bilateral framework agreements with countries receiving bilateral assistance through USAID. All of these agreements stipulate that goods (i.e., “supplies, materials, equipment, or other property”) imported or introduced for use in assistance projects shall be free from any tariffs, customs duties, import taxes, and other taxes or similar charges, and more than half also prohibit taxation of goods purchased in the country (GAO, 2004).

17 For a general critique of tariff and tax waivers on foreign financed products see Chambas (2005).

Box 6. The IFC/GEF Photovoltaic Market Transformation Initiative

The Photovoltaic Market Transformation Initiative (PVMTI) is a strategic joint initiative of the International Finance Corporation (IFC) and the Global Environment Facility (GEF) aimed at accelerating the penetration of PV technology "as a renewable and emission-free source of electric power in developing countries, especially for off-grid applications." In operation since 1998, the GEF has approved USD 30 million for the project, of which USD 25 million has been used for concessional investments in PV market-development projects in India, Kenya, and Morocco. (The remaining USD 5 million is reserved for implementation costs.) The investment period will run through 2005, and all programme activity and recovery of funds is due to be completed by June 2008.

The PVMTI's main impact is expected to be in facilitating the success of companies intended to serve as good examples of viable PV businesses — with financial structures and business approaches that work — thus forming the basis for the long-term sustainability and replicability of the projects. Entrepreneurs receive assistance in drawing up business plans, following which they can apply for concessional financing. The initiative can provide debt, equity or loan guarantees to project sponsors, which are likely to be companies that target the sale or leasing, distribution, installation, and service of PV equipment. The IFC may also choose to co-invest with PVMTI in selected commercially viable projects. The PVMTI estimates that the total project investment stimulated by the initiative will be in the neighbourhood of USD 90-120 million.

Sources: Based on http://www.ifc.org/ifcext/enviro.nsf/Content/Photovoltaic and http://www.ifc.org/ifcext/enviro.nsf/e11ffa331b366c54ca2569210006982f/24b7345f65a9f88c85256dc200104943?OpenDocument

Complementary policy changes within countries can also have a tremendous influence on the benefits to be gained from liberalising trade in photovoltaic cells and modules and associated components. As numerous studies have shown, the market for renewable-energy based electric-generating technologies is influenced by a wide range of factors related to the way that electricity and competing fuels are priced, and the openness of electricity markets. As the bulk of solar-PV systems installed in developing countries are likely to be for off-grid use, the most important policies in the short term are probably those regulating services connected with the installation and servicing of equipment. But as the number and income of users increase, more and more owners of such installations may become interested in selling some of the electricity they produce back to the electricity grid. In those situations, the reform of electricity markets so as to allow the private supply of electric power may be necessary.

One other reform is also crucial: making the high cost of extending electricity transmission lines into rural areas more transparent. Noting that "most (if not all) of rural electrification programs around the world have been funded through implicit cross-subsidies (often from industrial to residential consumers and from urban to rural consumers)", Cabraal and Fitzgerald (2002, p. 3) point out:

> Because electricity is so desirable to the public, power-sector operations and rural lines extension are often highly politicized. Where politicians interfere with the orderly planning and running of programs by, for instance, directing that favored constituents constituents are connected first, or by preventing constituents from being disconnected for not paying their bills, rural electrification efforts can quickly become inefficient and a burden on the public budget or on power-sector finances.

Making the costs of extending grid lines to rural areas more transparent, and halting the practice of cross-subsidising their construction and maintenance, would reveal lower-cost ways of meeting the same objectives. Chile was an early pioneer in this regard, establishing a decentralised scheme (the "minimum subsidy vehicle") which awarded funds to those rural electrification projects that required the smallest payment per unit of social value (Jadresic, 2000). In many cases, the lowest-cost option was to install stand-alone power supplies (such as solar PV systems, small wind turbines or small hydroelectric stations) to homes, or to set up micro-scale grids, rather than to extend a transmission line.

Finally, in order to minimise problems associated with the disposal of solar PV system components at the end of their useful lives, mechanisms for collecting and recycling PV cells and storage batteries need to be in place. Lead-acid solar batteries are of particular concern, because of the toxicity and persistence of lead in the environment. The recovery of lead from such batteries is not difficult, however, and merchants able to recycle 12-volt car and lorry batteries already exist in most countries. Electric lighting facilitated by solar-electric systems may also reduce the consumption of disposable flashlight batteries (which often contain heavy metals), recycling options for which are much less prevalent than for larger batteries in developing countries.[18]

Wind turbines and pumps

The technology

A wind turbine is a machine that converts the kinetic energy in wind into mechanical rotation, which in turn drives an electrical generator. Wind turbines are made in a multitude of shapes and sizes, from small devices producing a few hundred watts of power to massive towers, the largest of which are rated at 5 000 000 watts (5 MW). Most commercial wind turbines, especially large ones, are horizontal-axis machines. The share of the market supplied by wind turbines that transfer mechanical rotation along a vertical axis is tiny. Large wind turbines are sometimes built in isolation, but in OECD countries most are installed in groups (wind farms) of ten or more, sometimes even in the hundreds.

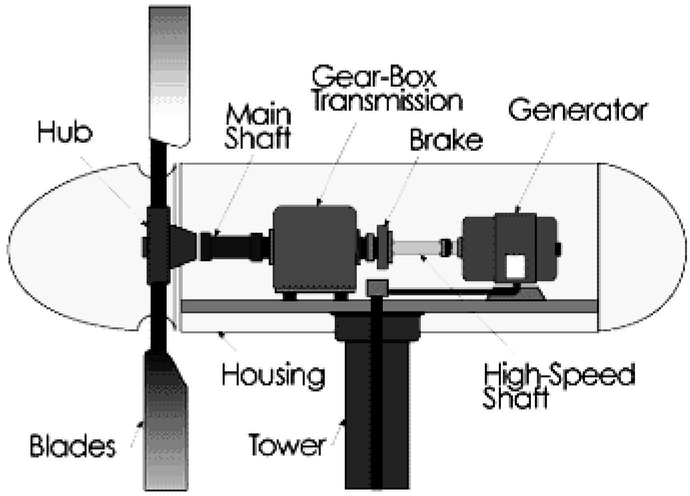
A wind pump captures wind energy in much the same way as a wind turbine, but is a much simpler device, using mechanical rotation to lift or pump water. Wind pumps can draw water from wells as deep as 200 metres. Wind-powered pumps have been in use for over 2000 years, and the technology has reached a mature state. While producing the transmission and drive train for a high-quality wind pump requires machine tools, the rotors and lattice towers can be produced in small-scale workshops.[19]

Figure 2 shows the main working elements of a wind turbine. The two or three blades (foreshortened in the Figure) that together with the hub make up the rotor, are the most expensive part of the machine. The turbine blades, the largest of which can reach more than 50 metres in length and weigh 15 tonnes or more, are often made of composite materials (e.g., graphite fiber in epoxy) or fibreglass, and require precision manufacturing techniques. The gearbox transforms the relatively slow rotation of the blades (30 to 60 rotations per minute (rpm)), into a speed required by the generator to produce electricity (1200 to 1500 rpm). Because gearboxes are costly and heavy, engineers are exploring direct-drive generators that would operate at lower rotational speeds without a gearbox. Until such generators are developed, most wind turbines use standard induction generators that produce 50- or 60-cycle AC electricity.

[18] http://www.self.org/shs_envir.asp

[19] http://igadrhep.energyprojects.net/Links/Profiles/WindPumps/WindPumps.htm

Figure 2. Partial side view of a wind turbine



Source: Iowa Energy Center, *Wind Energy Manual*, Ames, Iowa, 2005, p. 7
http://www.energy.iastate.edu/renewable/wind/wem/wem-07_systems.html

Production and trade in wind turbines and wind pumps

Energy Source Guides (http://energy.sourceguides.com/) lists some 1355 wind-energy "businesses" in the world, covering manufacturers, retail sales businesses, wholesale suppliers, system design, system installation, architectural services, non-profit organizations, trade associations, and other types of businesses. The production of large, utility-scale turbines (>50 kWe), however, is dominated by just a handful of companies. According to the Danish company BTM Consult, the four largest manufacturers accounted for 79% of global sales in 2004, as measured by rated generating capacity. The Danish company Vestas Wind Systems A/S maintained its historical lead, capturing 34% of the world market. Gamesa Eolica, of Spain, rose to second position, at 18%, followed by Germany's Enercon GmbH (16%) and the USA's General Electric (11%). The largest locally owned company based outside the OECD, Suzlon (India), supplied just under 4% of the market.

As a large wind turbine is normally assembled in place from its different elements, "production" of a wind turbine means the manufacturing of blades, hubs, gear boxes, towers and other components. These manufacturing activities are distributed not only within OECD countries but also across several developing countries. For example, Vestas, the most vertically integrated producer, has established factories not only throughout Europe, but also recently started manufacturing blades for MW-class turbines in Australia, and has decided in principle to establish local production facilities in China and North America (Vestas, 2005). Recently, Vestas RRB India Ltd., which is 49% owned by Vestas Wind System A/S, began manufacturing windmill controllers at a facility near Chennai, and plans to open a blade-manufacturing plant at the same site by the end of 2005. With these investments some 75% of the value added of the wind turbines the company sells into India's fast-growing market will be generated within the country (*The Hindu Business Line*, 2005).

Enercon GmbH, besides manufacturing in Germany, Sweden and Turkey, has invested in facilities in Brazil and India. Wobben Windpower Ceará Ltda., a subsidiary of Enercon, currently operates two plants in the Brazilian states of Sao Paulo and Ceara, where it produces 0.6-MW, 1.0-MW and 1.6-MW turbines for customers in South America, and components for export to Europe and elsewhere. Enercon India Limited is a 56:44 joint venture with an Indian company which manufactures complete wind turbines for the local market and exports blades to Europe.

Small wind turbines — generally those rated at 50 kW or smaller — are often manufactured in one place and shipped as a kit for assembly. It is unknown precisely how many companies are involved in their production, but barriers to entry are presumably lower than for large turbines. The World Wind Energy Association has so far identified over 35 manufacturers of small wind turbines, including several in southern Africa, China and India. Koenemann and Lehmann (2005) estimate that there are over 100 manufacturers world-wide, of which about 30 are in China alone. The number of commercial manufacturers of wind pumps appears to be fewer than of small wind turbines, but many of them are located in developing countries.[20] One company, based in Nicaragua, is producing a rope wind pump that costs much less than a traditional "Aeromotor" wind pump, and is simpler to erect and maintain; more than 100 systems have been installed in Nicaragua and the technology is now spreading to other countries in Latin America (de Jongh and Rijs, 1999).[21]

On a country basis, Denmark is by far the dominant exporter of *complete* wind electric generating sets (as they are called in the statistics), accounting for 95% of world trade in 2003, in total worth USD 1.1 billion. The next-largest exporter was Brazil (with exports worth USD 2 million), followed by India (USD 0.7 million). Trade in components of large wind turbines, especially blades, towers and generators, probably exceeds that of complete wind turbines[22], but the available statistics are not sufficiently detailed to be able to distinguish trade in these items from other products classified under the same HS subheadings. Because of the nature of investment in the industry, much of the international trade that takes place in the components of large wind turbines is internal to the major multinational wind-turbine companies.

Potential implications of liberalising trade in wind turbines and wind pumps

As with solar-PV systems, the beneficiaries of liberalising trade in wind turbines and wind pumps would first and foremost be consumers of electricity, especially those currently living in countries where tariffs on these machines are high (e.g., 15% or greater). Judging from Annex Table 4, these would include Brunei, Cambodia, India, Maldives, Mexico, Nepal, Nigeria, Romania, Tanzania, Thailand and Yemen. While some aid-supported, utility-scale wind turbines may already be entering these countries duty-free, it is likely that many imports of smaller-scale wind turbines are currently subject to import tariffs.

On the production side, a large number of companies based in OECD countries would benefit from any extra sales generated by trade liberalisation of wind turbines and their components. So, too, would people working for local subsidiaries and joint ventures of these companies in countries like Brazil, China and India. Many other developing countries could become involved in manufacturing wind turbines as their own regional markets grow. Many of the components of wind turbines are bulky to ship, which works to the advantage of local production.

The environmental effects of liberalising trade in wind-turbine technology would depend in part on the degree to which wind turbines replace other means of producing electricity. Wind turbines emit no emissions while operating, except for some noise. Other disruption to the environment may be associated with the construction of the concrete bases into which larger turbines are set, and the construction and use of access roads. The concrete requirement, at roughly 0.3 cubic metres per kilowatt, is not insignificant: 700 MW of wind turbines (the capacity of a single, new coal-fired power plant) would use 210 000 cubic

20 The Intergovernmental Authority on Development (http://igadrhep.energyprojects.net/) lists seven manufacturers and suppliers of wind pumps in Africa.

21 See also www.gamos.demon.co.uk/just%20gamos%20homepage/henkfnl2.htm

22 The net turnover of the Vestas Group alone was EUR 1.6 billion (USD 1.9 billion) in 2003. As 85% of Vestas' sales of wind turbines are for export, and its global market share in 2003 was 32%, this suggests that a much larger proportion of sales of wind turbines take place in the form of components.

meters — enough to cover 10 international soccer pitches to a depth of 3 metres. Life-cycle studies (World Energy Council, 2004) suggest that emissions of CO_2 and air pollutants per kilowatt-hour generated are slightly less than from solar photovoltaic systems (on a full life-cycle basis), and much lower than from fossil-fuel electricity plants.

Complementary policies

For off-grid applications of wind power, many of the policy considerations discussed above for solar PV systems apply. But given that, in value terms, the bulk of wind turbine capacity produced in the world is for generating high-voltage electricity for central power grids, policies relating to the electricity sector as a whole have a critical influence on the extent to which economic opportunities for wind-generated electricity can be fully exploited.

Reforms of electricity sectors often include one or more of the following: vertical unbundling (separating the ownership of generation, transmission and distribution); horizontal unbundling (breaking up private or public monopoly control over service categories or geographic areas); and market pricing of bulk-power sales (Cabraal and Fitzgerald, 2002). Such reforms, as well as more targeted policies (Box 7), have proved instrumental in creating a more favourable investment climate for companies specialising in the production of power from new energy sources and technologies, including wind power. Restructuring, and the introduction of greater competition into the electricity market, has also tended to increase public involvement in energy choices, often to the benefit of cleaner and less-obtrusive electricity supply solutions (G8 Renewable Energy Task Force, 2001a). And, by fundamentally altering the roles of key stakeholders, the financial support provided by states to particular technologies may become more transparent, facilitating the elimination of programmes that no longer serve the public interest.

Box 7. Targeted policies to promote on-grid renewable-energy-based electric power

OECD countries have been promoting the expansion of wind power (and other on-grid sources of electricity produced from renewable energy) through numerous policies. Grants for research and development, tax concessions and other investment incentives were important in the early years of the industry. Nowadays, the policies that are providing the greatest stimuli are those that affect the market for renewable-based electricity itself. The two main policies of this sort are “feed-in” electricity tariffs and quota schemes.

The greatest exponent of feed-in tariffs has been Germany. Its Electricity Feed-in Law was introduced in 1991 and has since been modified twice. The Law has two components. First, operators of electricity distribution networks must provide renewable-energy generators with access to their grids and charge them only actual connection costs. Second, the grid owners have to pay the renewable-energy generators a price for their electricity that is set at a level higher than the market price for electricity generated from non-renewable energy sources, such as coal. Thanks to the security afforded investors by its feed-in law, Germany has more wind capacity than any other country: 16 600 MW as of the end of 2004.

Quota schemes normally involve an obligation on electricity distribution companies to obtain a specified percentage of the electricity that they sell to customers from renewable-energy sources. In 2002, for example, the UK set itself a target to generate 3% of its electricity from renewable sources in 2002, 10% by 2010 and 15% by 2015. Suppliers can meet this obligation by contracting to buy electricity from renewable-energy generators (receiving “green certificates” in return) or by paying a “buy-out” price to a central fund. The proceeds of the buy-out fund are distributed to those suppliers that have obtained the requisite number of green certificates. Compared with feed-in tariffs, quota schemes are more cost-effective.

Some developing countries are adopting similar policies. India’s Electricity Act 2003, for example, has several provisions intended to accelerate the emergence of private electricity production from non-conventional power sources. These include obligations on the state electricity regulatory commissions (SERCs) to allow access to their electricity grids, and to obtain a specified percentage of the total electricity consumption in their areas from cogeneration plants or renewable sources of energy. As of mid-2005, seventeen Indian states had announced policies allowing grid access and establishing buy-back policies for electricity sold by private-sector generators.*Source:* Based on “Renewable Energy for India”, http://www.reeep.org/index.cfm?articleid=1193

Countries liberalising trade in wind turbines will also naturally be concerned about increasing the share of related value-adding activities. Vocational training in the maintenance and operation of wind turbines is one investment that is likely to pay off, for example. Forcing the situation through trade-related investment measures, such as local-content obligations on sales (Box 8), is not only economically a second-best approach, but is also inconsistent with the WTO Agreement on Trade-Related Investment Measures. Commenting on China's local-content regime, one observer (Lewis, 2005) concludes that, "[r]ather than a fixed percentage localisation requirement, project evaluators should design criteria that more flexibly award creative methods for combining advanced international technology with local materials and integrating locally-manufactured components, and particularly methods that include collaborative innovation and development between foreign and Chinese companies."

Box 8. China's local-content requirement for wind turbine concessions

In 2003, China instituted a policy of granting 25-year concessions to suppliers of wind power through competitive bids. Initially the Government's guidelines stipulated that proposed projects be 100 MW in size, and use turbines over 600 kW in capacity, with a minimum 50% domestic content for concession-related projects. Effective mid-2005, a 70% minimum domestic content requirement became applicable for *all* new wind projects in China, unless a written agreement had been signed previously. This requirement was accompanied by a change in the Chinese tariffs intended to favour domestic production of wind turbines. Import duties are 3% for individual parts, 8% for assembled components, and 17% for entire pre-assembled turbines. Winning bidders of concessions benefit from fast-tracking of approvals to develop the selected project site, guaranteed grid interconnection, financial support for grid extension and access roads, and preferential loans and tax treatment.

The first five projects were awarded after two rounds of bidding in 2003 and 2004, resulting in over 550 MW of new wind turbine capacity. A third round of concession bidding took place in 2005. One of the concessions, from the Chinese company Jiangsu Unipower Wind Power Co. Ltd. (for 50, 2.0-MW wind turbines for the Rudong Wind Power Concession project), was awarded to the Danish company, Vestas. To meet the local-content requirement, Vestas is building a blade factory in China. In addition, in February 2005, the company opened a Strategic Purchasing Office in Shanghai to source the purchase of both raw materials and components from Chinese suppliers.

Sources: Lewis (2005); "Growing support for wind in China", *VestasGlobal*, April 2005, pp. 14-16, www.vestas.com/pdf/publikationer/VestasGlobal/no3/UK_VestasGlobal0305.pdf; Eric Martinot, "Renewable energy in China", http://www.martinot.info/china.htm (page updated 13 November 2005)

Concluding remarks

This analysis has undertaken a largely qualitative examination of trade in renewable energy and in the technologies used to exploit it. The results at this stage should be regarded as indicative, as statistics on trade in renewable energy technologies, and particularly their components, are incomplete. What the statistics do show is that while OECD countries still account for the bulk of world trade in renewable-energy technologies, especially the most technically advanced parts of those technologies, new investments in manufacturing are taking place in developing countries, and several companies have started to emerge as regional or even global suppliers. There are now also many small and medium-sized companies around the world — in both developed and developing countries — that make their business marketing and servicing renewable-energy-based systems scaled to the needs of households or small communities.

Beyond the export interest developing countries might have in renewables, the environmental and developmental benefits that could be derived from reducing tariffs on them are perhaps even more important. These include making forms of energy that are cleaner than the fuels and technologies currently in use more affordable, thus helping to accelerate the pace or rural electrification.

For the benefits of reducing tariffs to be realised, however, additional reforms at the domestic level may be required. In the area of energy policy, creating a more favourable investment climate for companies specialising in the production of power from new energy sources and technologies, and fostering competition in the market for electricity, are both crucial. And, to enable off-grid power sources to fill their proper niches, governments should strive for transparency on the costs of extending grid lines to rural areas, and halt the practice of cross-subsidising the construction and maintenance of such grids.

Regarding the environmental effects of adopting a more liberal trading regime for a particular good or set of goods, ultimately these will be specific to each country and influenced by broader policies. To avoid unsustainable exploitation of energy derived from biomass, for example, governments may need to strengthen their regimes for managing and protecting those resources. Because many renewable-energy-based systems involve electronic components and storage batteries, new systems for collecting and disposing or recycling of parts and materials may be required. Educational and training programmes may be needed as well, to explain the benefits of particular fuels and technologies and to demonstrate their proper use and disposal.

Analysis of the effects of liberalising trade in renewable-energy products and associated goods could be refined through additional research in several areas. For one, this report covers only one fuel and two representative technologies. Expanding the coverage to include other fuels or technologies — e.g., biodiesel, small hydroelectric systems, solar water heaters, solar concentrators, or geothermal-energy systems — would likely identify additional environmental and developmental benefits from trade liberalisation in this area. More information on the comparative life-cycle performance and costs of renewable energy and associated technologies could be provided. And more examples of improvements brought about by the installation of renewable-energy-based systems in developing countries could also be added. With regard to trade, further research may reveal additional investments being undertaken in the production of goods related to renewable energy in developing countries.

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ANNEX TABLES

Annex Table 1. Primary renewable energy products and technologies for harnessing renewable energy

HS heading or code	*Product description* [renewables component]
22.07	**Undenatured ethyl alcohol of an alcoholic strength by volume of 80% volume or higher; ethyl alcohol and other spirits, denatured, of any strength.**[1]
38.24	**Products, preparations and residual products of the chemical or allied industries, incl. those consisting of mixtures of natural products, n.e.s . (excl. binders for foundry moulds and cores; naphthenic acids, their water-insoluble salts and their esters; non-agglomerated metal carbides mixed together or with metallic binders; prepared additives for cements, mortars and concretes; non-refractory mortars and concretes; sorbitol).**
3824.90 (ex)	– Other. [Biodiesel and waste fats and oil suitable as a fuel.]
44.01	**Fuel wood, in logs, in billets, in twigs, in faggots or in similar wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated pellets or similar forms.**
4401.10	– Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms.
4401.30 (ex)	– Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms [Artificial logs made from pressed sawdust; wood waste suitable as a fuel.]
4402.00	Wood charcoal (including shell or nut charcoal), whether or not agglomerated. [Wood, shell or nut charcoal used for fuel.]
84.10	**Hydraulic turbines, water wheels, and regulators therefor.**
8410.11	– Of a power not exceeding 1,000kW.
8410.12	– Of a power exceeding 1,000 kW but not exceeding 10,000 kW.
8410.13	– Of a power exceeding 10,000 kW.
8410.90	– Parts, including regulators.
84.12	**Other engines and motors.**
8412.80 (ex)	– Other [Steam engines; windmills without pumps.]
8412.90 (ex)	– Parts [Parts for steam engines and windmills.]
84.13	**Pumps for liquids, whether or not fitted with a measuring device; liquid elevators.**
8413.81 (ex)	– Other pumps; liquid elevators — Pumps —— [Windmill pumps]
84.19	**Machinery, plant or laboratory equipment, whether or not heated (excluding furnaces, ovens and other equipment of heading 85.14), for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, distilling, rectifying, sterilising, pasteurising, steaming, drying, evaporating, vaporising, condensing or cooling, other than machinery or plant of a kind used for domestic purposes; instantaneous or storage water heaters, non-electric.**
8419.19 (ex)	– Instantaneous or storage water heaters, non-electric — other [solar water heaters]

HS heading or code	*Product description* [renewables component]
85.02	**Electric generating sets and rotary converters.**
8502.31	– Other generating sets — Wind powered
8502.39 (ex)	– Other generating sets — Other [a generating set combining an electric generator and either a hydraulic turbine or a Sterling engine]
85.41	**Diodes, transistors and similar semiconductor devices; semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes; mounted piezo-electric crystals.**
8541.40 (ex)	– Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes [Photovoltaic cells and modules.]

1. Ethyl alcohol, only some of which is classified under HS heading 22.07 and is used for fuel, is covered by the Agreement on Agriculture. It is included in this list only for completeness.

Source: OECD Secretariat, based on the 2002 edition of the Harmonized System.

Annex Table 2. Common components of renewable-energy based systems

HS heading or code	*Product description* [renewables component]
84.02	**Steam or other vapour generating boilers (other than central hot water boilers capable also of producing low pressure steam); super-heated water boilers.**
8402.11	– Water-tube boilers with a steam production exceeding 45 tonnes per hour.
8402.12	– Water-tube boilers with a steam production not exceeding 45 tonnes per hour.
8402.19	– Other vapour-generating boilers, including hybrid boilers.
84.13	**Pumps for liquids, whether or not fitted with a measuring device; liquid elevators.**
8413.50 (ex)	– Other reciprocating positive displacement pumps [DC-powered water pumps]
8413.70 (ex)	– Other centrifugal pumps [DC-powered submersible water pumps]
84.16	**Furnace burners for liquid fuel, for pulverised solid fuel or gas; mechanical stokers, including their mechanical grates, mechanical ash dischargers and similar appliances.**
8416.30	– Mechanical stokers, including their mechanical grates, mechanical ash dischargers and similar appliances [Mechanical stokers and related appliances used for burning biomass.]
8416.90	– Parts [Parts for mechanical stokers and related appliances used for burning biomass.]
85.01	**Electric motors and generators (excluding generating sets).**
8501.31	– Other DC motors; DC generators — Of an output not exceeding 750 W
8501.61	– AC generators (alternators) — Of an output not exceeding 75kVA
85.04	**Electrical transformers, static converters (for example, rectifiers) and inductors.**
8504.40 (ex)	– Static converters [Inverters (for converting DC power to AC power)]
85.07	**Electric accumulators, including separators therefor, or not rectangular (including square).**
8507.20 (ex)	– Other lead-acid accumulators [solar batteries]
85.37	**Boards, panels, consoles, desks, cabinets and other bases, with two or more apparatus of heading 85.35 or 85.36, for electric control or the distribution of electricity, including those incorporating instruments or apparatus of Chapter 90, and numerical control apparatus, other than switching apparatus of heading 85.17.**
8537.10 (ex)	– For a voltage not exceeding 1 000 V [Charge controllers (for storage batteries)]
85.41	**Diodes, transistors and similar semiconductor devices; semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes; mounted piezo-electric crystals.**
8541.40 (ex)	– Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes [white-light emitting diodes.]
90.26	**Instruments and apparatus for measuring or checking the flow, level, pressure or other variables of liquids or gases (for example, flow meters, level gauges, manometers, heat meters), excluding instruments and apparatus of heading 90.14, 90.15, 90.28 or 90.32.**
9026.80 (ex)	Other instruments or apparatus [Anemometers]

Source: OECD Secretariat, based on the 2002 edition of the Harmonized System.

Annex Table 3. World exports of, and maximum tariffs applied to, renewable fuels and renewable-energy technologies

Product HS code	*Product description*	*Value of world exports in 2003 for all goods under same HS subheading (USD millions)*[2]	*Estimated value of renewables component (USD millions)*[3]	*Share of exports from non-OECD countries (%)*	*Maximum applied ad valorem tariff*[4]
2207.10	Undenatured ethyl alcohol, ≥ 80% strength (for fuel)[1]	960	480	45	300%
2207.20	Denatured ethyl alcohol and other spirits, any strength (for fuel)[1]	222	110	19	125%
3824.90	Biodiesel	19 118[5]	175	52	30%
4401.30	Sawdust and wood waste and scrap	439	145	18	100%[6]
4402.00	Wood, shell or nut charcoal	250	250	56	100%[6]
8410.11	Hydraulic turbines, < 1 MW	28	28	16	33%
8410.12	Hydraulic turbines, ≥ 1 MW but < 10 MW	27	27	16	33%
8410.13	Hydraulic turbines, > 10 MW	47	47	15	25%
8410.90	Parts for hydraulic turbines	436	436	19	25%
8412.80	Windmills	277	10	10	35%
8413.81	Windmill pumps	2 164	100	14	43%
8416.30	Mechanical stokers, etc. for biomass	57	25	13	35%
8419.19	Solar water heaters	777	200	5	50%
8501.31	Other DC motors; DC generators, output < 750 W	2 801	14	12	35%
8501.61	AC generators or alternators, output < 75 kVA	347	3	16	35%
8502.31	Wind-powered electric generating sets	1 128	1 128	< ½	35%
8541.40	Solar cells and modules	8 119	900	19	35%
	Total	20 422	~ 4 000	21	NA

[1.] Ethanol (HS 2207.10 ex and HS 2207.20 ex) is covered by the Agreement on Agriculture and is included here only for completeness.

[2.] Including exports from individual EU Member States to other EU Member States.

[3.] For description of the renewables component, see Table 1.

[4.] Applied by WTO members or observers. Neither specific-rate tariffs nor their ad valorem equivalent are included in this column.

[5.] Some biodiesel may have also been traded under HS 1516.20 in 2003.

[6.] These tariffs rates are applied by certain observers to the WTO; among WTO members, the highest applied tariffs are in the order of 35%.

Source: OECD compilation based on data from COMTRADE (trade values), TRAINS (applied tariff rates), and WTO (bound tariff rates).

Annex Table 4. Leading exporters of, and highest tariffs applied to, renewable energy and renewable-energy technologies

Product [HS code]	*Leading Exporters, 2003*	*Export Value ($000)*	*Importers[1] with the highest level of duty*	*Applied tariff, in % (data year)*	*Bound Rate, in %[2]*
Fuel wood	***World***	***142 040***	*Libya*	100 (2002)	—
[4401.10]	*OECD countries*	*82 747*	*Seychelles*	100 (2001)	—
	Estonia	14 303	Angola	35 (2002)	60
	Latvia	14 143	Solomon Islands	35 (1995)	80
	South Africa	6 752	Cameroon	30 (2002)	—
	Croatia	5 822	C. African Rep.	30 (2002)	—
	Lithuania	3 949	Chad	30 (2002)	—
	Russian Fed.	3 423	Congo, Rep.	30 (2002)	—
	Romania	3 141	Equatorial Guinea	30 (2002)	—
	Slovenia	2 993	Gabon	30 (2002)	15
	Bulgaria	1 396	Maldives	30 (2003)	30
	Belarus	1 196	Romania	30 (2001)	30
Wood	***World***	***250 127***	*Libya*	100 (2002)	—
Charcoal	*OECD countries*	*109 873*	*Seychelles*	100 (2001)	—
[4402.00]	China	63 494	Angola	35 (2002)	60
	Argentina	13 096	Solomon Islands	35 (1995)	80
	South Africa	11 455	*Bahamas, The*	30 (2002)	—
	Malaysia	10 032	Cameroon	30 (2002)	—
	Bulgaria	7 462	C. African Rep.	30 (2002)	—
	Singapore	6 861	Chad	30 (2002)	—
	Romania	4 671	Congo, Rep.	30 (2002)	—
	Latvia	4 521	Equatorial Guinea	30 (2002)	—
	Namibia	3 002	Gabon	30 (2003)	15
	India	2 641			
Hydraulic	***World***	***28 239***	Djibouti	33 (2002)	40
turbines,	*OECD countries*	*23 695*	India	25 (2004)	25
< 1 MW	— of which Mexico	*230*	*Vanuatu*	25 (2002)	—
[8410.11]	Slovenia	1 356	Bermuda[4]	22.25 (2001)	—
	India	1 014	*Belarus*	15 (2002)	—
	China	689	Cambodia	15 (2003)	—
	Israel	250	Colombia	15 (2004)	35
	Aruba	218	Romania	15 (2001)	35
	Argentina	204	*Russian Fed.*	15 (2002)	—
	South Africa	165	Rwanda	15 (2003)	35
	Singapore	160	*Seychelles*	15 (2001)	—
	Peru	151	Venezuela	15 (2004)	35
Hydraulic	***World***	***27 424***	Djibouti	33 (2002)	40
turbines,	*OECD countries*	*22 941*	*Vanuatu*	25 (2002)	—
> 1 MW	— of which Mexico	*187*	India	25 (2004)	25
but < 10 MW	Malaysia	2 805	*Belarus*	15 (2002)	—
[8410.12]	China	1 274	Cambodia	15 (2003)	—
	India	178	Colombia	15 (2004)	35
	Bulgaria	92	Romania	15 (2001)	35
	Peru	48	*Russian Fed.*	15 (2002)	—
	Singapore	36	Rwanda	15 (2003)	100
	Bolivia	19	*Seychelles*	15 (2001)	—

Product [HS code]	*Leading Exporters, 2003*	*Export Value ($000)*	*Importers[1] with the highest level of duty*	*Applied tariff, in % (data year)*	*Bound Rate, in %[2]*
	Belarus	13	Venezuela	15 (2004)	35
	Brazil	6	Brazil	14 (2004)	35
Hydraulic turbines, > 10 MW [8410.13]	***World***	***46 848***	India	25 (2004)	25
	OECD countries	*40 041*	*Vanuatu*	25 (2002)	—
	— of which Mexico	815	*Belarus*	20 (2002)	—
	— of which Turkey	4	Cambodia	15 (2003)	—
	Slovenia	5 695	Colombia	15 (2004)	35
	Russian Federation	670	Romania	15 (2001)	35
	Bulgaria	244	*Russian Fed.*	15 (2002)	—
	India	119	Rwanda	15 (2003)	100
	Singapore	72	*Seychelles*	15 (2001)	—
	Malaysia	5	Venezuela	15 (2004)	35
	South Africa	2	Brazil	14 (2004)	35
			Mexico	0–13 (2004)	35
Parts for Hydraulic turbines, incl. regulators [8410.90]	***World***	***436 398***	India	25 (2004)	25
	OECD countries	*351 569*	*Vanuatu*	25 (2002)	—
	— of which Mexico	11 019	*Belarus*	15 (2002)	—
	Slovenia	23 989	Cambodia	15 (2003)	—
	Brazil	14 018	Romania	15 (2001)	15
	China	10 178	*Russian Fed.*	15 (2002)	—
	Romania	9 006	Brazil	14 (2004)	25–35
	Russian Federation	7 760	Mexico	0–13 (2004)	35
	Malaysia	5 199	Burundi	12 (2002)	—
	Singapore	4 613	Bahrain	10 (2001)	35
	Israel	2 056	Bolivia	10 (2004)	40
	India	1 671	Camaroon	10 (2002)	—
Instantaneous or storage water heaters, non-electric, non gas [8419.19]	***World***	***777 167***	Dominica	20–60 (2003)	—
	OECD countries	*739 308*	Iran, Islamic Rep.[3]	50 (2004)	—
	— of which Mexico	*198 994*	Morocco	2.5–50 (2003)	40
	— of which Korea	*4 997*	Syrian Arab Rep.[4]	50 (2002)	—
	— of which Turkey	*1 929*	Tunisia	10–43 (2004)	—
	Israel	16 836	*Bahamas, The*	40 (2002)	—
	China	4 953	Burundi	40 (2002)	—
	Malaysia	3 857	Egypt, Arab Rep.	30–40 (2002)	50–60
	New Caledonia	3 550	Zimbabwe	5–40 (2002)	—
	Slovenia	1 861	China	35 (2004)	35
	Thailand	1 305	St. Lucia	20–35 (2003)	50–93
	Singapore	1 152	Djibouti	33 (2002)	40
Wind powered electric generating sets [8502.31]	***World (OECD est.)***	***1 128 505***	*Bahamas, The*	35 (2001)	—
	OECD countries	*1 123 859*	Bermuda[4]	33.5 (2004)	—
	— of which Denmark	*964 965*	India	25 (2004)	25
	— of which Korea	23	Mexico	3–23 (2004)	35–40
	Brazil (OECD est.)	2 000	Brunei	20 (2003)	40
	India	771	Maldives	20 (2003)	30
	Singapore	678	Thailand	20 (2003)	—
	Namibia	95	Cambodia	15 (2003)	—
	Tunisia	69	Nepal	15 (2004)	—
	South Africa	33	Nigeria	15 (2002)	—

Product [HS code]	*Leading Exporters, 2003*	*Export Value ($000)*	*Importers[1] with the highest level of duty*	*Applied tariff, in % (data year)*	*Bound Rate, in %[2]*
	Malaysia	23	Romania	15 (2001)	35
	China	16	Tanzania	15 (2003)	—
			Yemen	15 (2000)	—
Photo-sensitive semiconductor devices, Including Photovoltaic cells; light-Emitting Diodes [8541.40]	***World***	***8 960 227***	*Bahamas, The*	35 (2002)	—
	OECD countries		Cambodia	35 (2003)	—
	— of which Korea	189 117	Solomon Islands	35 (1995)	80
	— of which Mexico	64 555	Djibouti	33 (2002)	40
	Malaysia	664 015	Libya	25 (2002)	—
	Hong Kong, China	663 557	Maldives	25 (2003)	30
	China	322 799	*Vanuatu*	25 (2002)	—
	Singapore	302 973	*Belarus*	20 (2002)	—
	Thailand	110 705	Ethiopia	20 (2002)	—
	India	57 301	Brazil	14–16 (2004)	35
	South Africa	29 857	India	15 (2004)	0
	Russian Fed.	11 947	Nepal	15 (2004)	—

1. Italics indicates that the country is an observer to the WTO

2. — = unbound or not applicable (in the case of observers and non-members).

3 The Islamic Republic of Iran applied for Observer status in 2001, a request that has not been granted to date.

4 Bermuda and the Syrian Arab Republic are neither WTO Members nor Observers to the WTO.

Source: OECD compilation based on data from COMTRADE (trade values), TRAINS (applied tariff rates), and WTO (bound tariff rates).

APPENDIX: INTERNATIONAL EFFORTS TO PROMOTE TRADE IN RENEWABLE ENERGY AND RELATED TECHNOLOGIES

Because of the importance of minimising barriers to trade in renewable-energy technologies, several inter-governmental organisations and regional bodies are already addressing certain of these issues. A number of projects are being conducted under the umbrella of the Johannesburg Renewable Energy Coalition (JREC).[23] Formed in August 2002 at the Johannesburg World Summit on Sustainable Development, the JREC's membership includes Iceland, New Zealand, Norway, Switzerland and Turkey and the European Union. During the first week of June 2004 Germany, one of the JREC's members, hosted a major International Conference for Renewable Energies, in Bonn.

Another public-private partnership launched at the Johannesburg Summit is the Renewable Energy & Energy Efficiency Partnership (REEEP). In June 2004, the REEEP was formally established as a legal entity in Austria with the status of an International NGO. The partnership is funded by a number of governments, including Austria, Canada, Ireland, Italy, Spain, the Netherlands, the United Kingdom, the United States and the European Commission. One of its primary goals is to get developing countries to use energy in a more efficient way and increase the share of indigenous renewable resources in their total energy mix. REEEP helps structure policy initiatives for clean energy markets and facilitates the financing energy projects it considers to be sustainable. By providing opportunities for concerted collaboration among its partners, it aims to create a more vibrant market for renewable energy and energy efficiency.

The International Energy Agency (IEA) has also taken an interest in reducing barriers to trade in renewables. Work undertaken by its Renewable Energy Unit (IEA/REU) in 2003 showed that, while tariffs applied by OECD countries on goods such as wind turbines, solar water heaters and photovoltaic cells are low, they remain high (above 15%) in quite a few developing countries. Even among OECD countries, differences in national requirements relating to safety and electrical performance, and in related procedures for conformity assessment, may act as non-tariff barriers to trade (IEA, 2004b). The IEA/REU has also been active in promoting a regional model (starting with the Mediterranean region) for liberalising trade in renewable energy.

Various IEA Implementing Agreements are also looking at trade barriers. For example, IEA Bioenergy (http://www.ieabioenergy.com/) is currently one year into a three-year project (Task 40) looking at "Sustainable International Bioenergy Trade: Securing Supply and Demand". Among the specific aims of this project are:

- to document trade experiences (e.g. of Sweden, Finland, Brazil, the Netherlands), and survey the possible effects on existing markets for pulp wood, forestry and agricultural products and residues, of trade in energy derived from renewable biomass;

- to identify existing barriers to development of a (global) market in biofuel commodities, and to identifiy strategies to overcome these barriers.

23 Its declaration can be found at http://europa.eu.int/comm/environment/wssd/energy_declaration.pdf.

Meanwhile, the Secretariat of the Energy Charter is investigating ways both of promoting growth in the supply of renewable energy and in lowering barriers to trade.[24] On 2 November 2004 the Charter hosted an "Expert Meeting on Trade Friendly Promotion of Renewable Energy" (www.encharter.org//index.jsp?psk=07&ptp=tDetail.jsp&pci=162&pti=9). Currently the Energy Charter is investigating the compatibility of various policies and measures that aim at promoting the use of renewable energy with the provisions of the trade rules of the Energy Charter Treaty and the WTO (EEC code: CS (03) 765 T 67/Rev.1, 2 April 2004).

In the UN system, four inter-governmental organisations have programmes relating to renewable energy:

- *Food and Agricultural Organization of the United Nations (FAO):* The FAO has been engaged in numerous activities related to bioenergy since the 1970s, sponsoring studies and establishing a number of bioenergy information systems and databases, projects and partnerships. Recently it has called for an International Action Plan on Bioenergy that would bring together disparate sources of information on biomass energy globally and mobilise existing technologies. A meeting will be convened in Rome later in 2005 to elaborate ideas for the Action Plan.

- *United Nations Conference on Trade and Development (UNCTAD):* UNCTAD has identified renewable energy products, including bio-fuels, as among the new and dynamic sectors of world trade. It hosted an Expert Meeting on New and Dynamic Sectors from 7 to 9 February 2005 in Geneva, devoting one of the days to renewables.

- *United Nations Economic Commission for Europe (UN-ECE):* The UN-ECE's Committee on Sustainable Energy (http://www.unece.org/ie/se/com.html) focuses on norms, standards, and labelling and classification systems relating to renewable energy.

- *United Nations Environment Programme (UNEP):* UNEP's Energy Branch focuses on the needs of developing and transition economies in various facets of renewable energy technology research, development, and commercialisation. Its Solar and Wind Energy Resources Assessment (SWERA) is helping countries around the world to identify areas of renewable energy potential. A specific bio-energy tool, RETScreen (developed in collaboration with Natural Resources Canada), provides data on renewable energy.

The World Bank Group (including the International Finance Corporation), finances a significant number of renewable-energy projects throughout the developing world, sometimes with private sector co-financing. It, together with the United Nations Development Program and UNEP form the three implementing agencies of the Global Environmental Facility (GEF), the largest source of funds for renewable energy in the developing world. As the financial mechanism for the United Nations Framework Convention on Climate Change (UNFCC), the GEF has provided about USD 900 million for more than 110 projects in 50 countries. This support has leveraged almost USD 6 billion in additional co-financing (GEF, 2004).

Numerous bilateral and regional programmes have also been established to promote renewable energy in developing countries. In 1995, for example, with the signing of the Barcelona Declaration, the EU

[24] The shared principles that underpin the Charter Treaty are non-discrimination, transparency and a commitment to the progressive liberalisation of international trade. The 1998 Trade Amendment expanded the Treaty's scope to cover trade in energy-related equipment, and set out a mechanism for introducing in the future a legally-binding stand-still agreement on customs duties and charges for energy-related imports and exports.

entered into wide-ranging partnership with its Southern and Eastern Mediterranean counterparts (Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, the Palestinian Authority, Syria, Tunisia and Turkey) aimed at establishing a Euro-Mediterranean free trade area by 2010. Co-operation in the field of energy lies at the heart of the economic partnership. Among the energy priorities for the period 2003-2006 is promoting the potential of renewable energy sources. In the Americas, the Renewable Energy in the Americas (REIA) initiative, supported by the Office of Sustainable Development and Environment of the Organization of American States (OSDE/OAS), has since 1992 facilitated long-term hemispheric co-operation in renewable energy and energy efficiency.