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Trade Flows, Barriers and Market Drivers in Renewable Energy Supply Goods

The Need to Level the Playing Field

By Veena Jha
Maguru Consultants and University of Warwick

ICTSD Global Platform on Climate Change, Trade and Sustainable Energy

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LIST OF ABBREVIATIONS AND ACRONYMS

ARRA	American Recovery and Reinvestment Act (Stimulus Bill)
CAFTA	Central America Free Trade Agreement
CBI	Caribbean Basin Initiative
CHP	Combined Heat and Power
COMTRADE	United Nations Commodity Trade Statistics Database
DANIDA	Danish Development Agency
ECN	Energy Research Centre of the Netherlands
EE	Energy Efficiency
EG	Environmental Good
EGS	Environmental Goods and Services
EU	European Union
EUR	Euro
FAMAE	Fatty-acid Mono-alkyl Esters
FDI	Foreign Direct Investment
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse Gas
GSP	Generalized System of Preferences
IGA	International Geothermal Association
UNFCCC	United Nations Framework Convention on Climate Change
HS	Harmonized System
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
kVA	Kilovolt Ampere
MFN	Most-favoured Nation
MW	Megawatt
NAFTA	North American Free Trade Agreement
NTB	Non-tariff Barrier
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturers
PV	Photovoltaic
REC	Renewable Energy Certificate
RES	Renewable Energy Supply
RET	Renewable Energy Technology
RFS	Renewable Fuel Standard
UNCTAD	United Nations Conference on Trade and Development
USD	US Dollar
USICT	United States International Trade Commission
WCO	World Customs Organisation
WITS	World Integrated Trade Solution
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

FOREWORD

Environmental goods and services (EGS) as a subset of goods and services was singled out for attention in the negotiating mandate adopted at the Fourth Ministerial Conference of the World Trade Organization (WTO) in November 2001. Increasing access to and use of EGS can yield a number of benefits including reduced air and water-pollution, improved energy and resource-efficiency and facilitation of solid waste disposal. Gradual trade liberalization and carefully-managed market openings in these sectors can also be powerful tools for economic development as they generate economic growth and employment, enable the transfer of valuable skills, technology, and knowhow, all of which are embedded in EGS. In short, well-managed trade liberalization in EGS can facilitate the achievement of sustainable development goals laid out in global mandates such as the Johannesburg Plan of Implementation, the UN Millennium Development Goals and various multilateral environmental agreements.

While Paragraph 31 (iii) of the Doha mandate calls for a reduction, or as appropriate, elimination of tariffs and non-tariff barriers (NTBs) on EGS, the lack of a universally-accepted definition on EGS has meant that trade delegates have struggled over the scope of goods and services that could be taken up for liberalization. Furthermore, while the aim of the EGS mandate is to liberalize, it provides no indication of the pace, depth or sequencing of liberalization vis-à-vis 'other' goods and services. A major fault line in the negotiations on environmental goods is the dispute over whether only goods intended solely for environmental protection purposes should be included, or if other goods that may have both environmental and non-environmental uses should also be incorporated. A number of developing countries are concerned about the inclusion of goods which they perceive to be only vaguely linked to environmental protection. They are also concerned about the import-led impacts of including a broad range of industrial goods on their domestic industries, employment and tariff revenues. In a broader context, a lack of movement on issues of interest to developing countries, particularly agriculture, also inhibits proactive developing country engagement in EGS negotiations.

Particular attention has been focused on the challenges of climate change and the widespread diffusion of climate-friendly technologies which are viewed as critically important in addressing these challenges. To the extent that the WTO negotiations on EGS can help identify and liberalize specific climate-friendly goods and services, they can enhance their wider diffusion. In the WTO context a number of challenges exist, as they do with many other environmental goods in identifying specific climate-friendly goods. This is partly related to the way climate-friendly goods are classified for the purposes of international trade negotiations and also to the fact that the same goods may have other uses in addition to climate-mitigation. Political economy considerations surrounding international trade negotiations indicate that it is will not be easy to liberalize any good or service even if it is important to climate change, and if doing so will also impact a broad range of industries in producing countries. Furthermore, trade-liberalization done in isolation may not necessarily generate greater trade flows in climate-friendly goods and services if the right policies and incentives that drive markets in these goods and services are missing. Hence, it would also be useful to identify the key market drivers of these goods and services that are related to domestic regulatory policies and measures.

In order to enable a better understanding of the patterns of trade flows and market drivers for technologies and associated goods, it is important as a first step to map key technologies and the associated goods that are important for climate mitigation. This needs to be done in a number of sectors. Thus, this paper by Dr. Veena Jha builds on a mapping exercise of technologies and associated goods in the renewable energy sector carried out by experts from the Energy Research Centre of the Netherlands (ECN) and their subsequent classification under the Harmonised System

(HS) customs codes at the 6-digit level undertaken by Mr Izaak Wind, an expert and former Deputy-Director at the World Customs Organisation (WCO). Similar mapping studies and customs classification exercises have already been carried out for climate-friendly technologies and associated goods in the building and transport sectors in order to feed into subsequent trade analyses for these sectors.

This paper points out the challenges in identifying goods used solely for renewable energy generation purposes for computing trade statistics. It also highlights goods for which identification is relatively easier and those sectors which appear to be more trade-intensive than others. In addition, it shows the key exporting and importing countries of renewable energy equipment in a range of sectors including solar, wind, hydro-electricity, geothermal, ocean and biomass. Finally, the paper assesses to what extent tariffs drive trade flows in these technologies, compared to a number of other policy drivers including regulations and incentives. Overall, the paper addresses the issue of the need for a level playing field, particularly for developing country producers. The playing field can be leveled through subsidies provided to renewable energy in the developed world being made available to developing countries while addressing the trade-distorting ones through WTO rules and disciplines. While subsidies need to be phased out over the long term it is important to recognize the importance of some of these subsidies at least in the short to medium term for market creation. All of these issues are important in the context of both the role of the WTO in generating conditions for free and fair trade in climate-friendly goods as well as for the United Nations Framework Convention on Climate Change (UNFCCC) negotiations in creating an enabling environment for markets and domestic demand for these goods, particularly in developing countries.

Dr. Veena Jha is a Visiting Professorial Fellow at the Institute of Advanced studies, University of Warwick, UK, and a research fellow at the International Development Research Centre, Canada. In addition, she is the Executive Director of Maguru Consultants Limited, London, UK. She has worked with the United Nations in various capacities for over twenty years. She was the Coordinator of an important UNCTAD/ DFID/Government of India initiative on 'Strategies and Preparedness for trade and Globalisation in India'. She has published twelve books on trade and development issues, articles in journals, and was a member of some consensus-building initiatives on trade and environment issues in the last decade. She has been a member of several national and international Advisory Boards, notably the United Nations Secretary General's Task Force on Millennium Development goals. She has served as an expert on technical committees of the Government of India, industry associations, and non-governmental organisations on trade and development issues.

The paper is part of a series of issue papers commissioned in the context of ICTSD's Environmental Goods and Services Project, which address a range of cross-cutting, country specific and regional issues of relevance to the current EGS negotiations. The project aims to enhance developing countries' capacity to understand trade and sustainable development issue linkages with respect to EGS and reflect regional perspectives and priorities in regional and multilateral trade negotiations. We hope you will find this paper to be stimulating and informative reading and useful for your work.

Ricardo Meléndez-Ortiz
Chief Executive, ICTSD

EXECUTIVE SUMMARY

In addressing the challenge of climate change, energy supply is of fundamental importance. Most forms of economic activity rely on some form of primary energy. Since the dawn of the industrial revolution reliance on fossil-fuels has been one of the main drivers of climate change. Thus, breaking the link between energy use and greenhouse gas emissions through a switch to more renewable forms of energy will not only be a huge step in addressing the problem of global warming but also serve to put economic growth onto a more low-carbon trajectory.

A number of renewable energy generation technologies are commercially available and many others are subject to research and development, some with a stronger likelihood of deployment than others. Therefore, this paper is essentially concerned with trade flows and barriers to commercially-available renewable energy generation technologies and their associated goods. It also identifies and examines the role of various market and trade drivers, including tariffs in the uptake of these technologies. The paper builds on a 2008 mapping study commissioned by the ICTSD and prepared by the Energy Research Centre of the Netherlands (ECN). The mapping study was also peer-reviewed by the IPCC IVth Assessment Report's Working Group III coordinating lead authors (Energy Supply Chapter). The objective of the mapping study was to identify key climate-mitigation technologies and associated goods relevant to the renewable energy supply sector. This is a sector that has been identified by the Intergovernmental Panel on Climate Change (IPCC) as one of the critical sectors for mitigation of greenhouse gas emissions. The renewable energy technologies that are covered in the mapping study include: solar energy; wind energy; ocean energy; geothermal energy; hydro power and biomass technologies (including those used in the production of biofuels).

Based on the mapping study, the associated goods were classified as part of an independent exercise under relevant Harmonised System (HS) customs codes at the 6-digit level. This trade analysis has been carried out on the basis of these identified HS codes. In addition to codes derived from the ECN mapping study, a few additional ones relevant to the renewable energy generation sector considered to be significant to the renewable energy sector (RES) have been added by the author. These include bio-ethanol, bio-diesel, and solar air-heaters. Solar water-heaters, parts and components that were deemed important were also included in certain cases, notably hydraulic turbine parts (for hydro-electric generation) and wind-turbine parts.

One of the key challenges for the trade analysis of RES goods is their inability in terms of customs classification purposes to be perfectly correlated with HS 6-digit product category codes to which they belong. Trade analysis on the basis of HS 6-digit codes are easier to analyze, as common codes and product descriptions are used by all WTO members. At a more detailed product-level (8 or 10 digit) which might capture the specific RES good in question, different countries use different codes and product descriptions. The trade figures shown in the tables presented in this paper have to be interpreted with extreme care as most 6-digit HS codes that cover "single-use" RES products also include unrelated products. Furthermore, in the case of components, total trade under the provisions of a particular 6-digit HS code is included. However, only a small part, if any at all, may be related to the deployment of renewable energy technologies and products. For instance, ball bearings are included because ball bearings are used in the production of wind turbines, but the trade figures will inevitably include total trade in ball bearings for any purpose.

Section One of the paper provides a background on the relationship between trade-induced economic activity and climate change. Trade-led economic growth can lead to improved living standards and, if assisted by sound policies, can also enable technological leapfrogging. On the other hand, the environmental effects of trade will also need to be managed. The focus needs to shift away from the issues of competiveness arising from the implementation of domestic climate policies to policies aimed at helping the innovation and dissemination of climate-friendly technologies through trade, subsidy-reform, appropriate regulatory policies, among other measures.

Section Two analyzes global trends in the renewable energy supply sector. It sketches the main actors in the sector, the main producers and the participation of developing countries in production and trade. Only about six percent of global energy is supplied by renewables. However, the sector is also a creator of jobs, a conservative estimate of which according to UNEP, totals nearly 23 million. European firms are dominant in the production of renewable energy and Europe is also a leading exporter of RES goods.

Based on an analysis of trade flows at the 6-digit level, it appears that intra-European trade in RES is among the highest in the world. Developing countries accounted for only 30 percent of global exports of RES products in 2007 and of these China by itself accounted for 40 percent. Developing countries account for a slightly higher 38 percent in terms of imports of RES products, although the top importers by and large are also OECD countries. Other prominent developing countries particularly in solar and wind energy technologies include Hong Kong, India, the Republic of Korea, Malaysia, Mexico, Singapore, South Africa and Thailand. Brazil and a few other developing countries also figure among the top ten exporters of bio-ethanol.

Section Three analyzes the top traders of equipment and components used in the RES sector and also examines tariffs in this sector. Solar and wind figure quite prominently in terms of traded technologies. In fact, the prominent example of ‘single-end use’ at the HS 6-digit level in the RES sector comprise wind-powered generating sets (HS 850231). Going beyond the 6-digit level ,another single end-use item appears to be solar panels categorized as an ‘ex-out’ under the 6-digit HS item-Photosensitive semiconductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels, and light-emitting diodes. With a few exceptions, the same countries that are among the top exporters for ‘single-end use’ products are also top exporters of a much larger list of products; this should not come as a surprise as exports of RES products are closely correlated with the capacity to export industrial goods in general.

An interesting finding is that the top deployers of renewable energy may not always be the same as the top traders of the technologies and components. This implies that the products being exported and imported are multiple-use items, only a part of which goes to the RES sector. Also products may be exported in response to conducive conditions in external markets, but may be too expensive to deploy on a large scale locally. The export of solar panels from China taking advantage of the feed-in tariffs existing in Germany and Spain is a good example. In some cases, exports are driven by factors that are largely unrelated to the deployment of renewable energy capacity in the exporting country, such as preferential access to export markets. For example, some Central American and Caribbean countries are among the top 20 exporters of bio-ethanol because the US import regime allows them, within certain limits, to import “wet” bio-ethanol from Brazil and Europe and export dehydrated ethanol to the US market

Similarly, there may or may not be a correlation between imports of RES products and local deployment of renewable energy. For example, nine of the 10 countries that expanded their wind energy capacity the most in 2008 are also included in the list of top importers of wind turbines. In cases where this correlation is not found, it again suggests either that the imports are made up of multiple-use items or that major parts of the industry are not tradeable. In wind, however, Asian manufacturers have increased their share of the market. Two Chinese manufacturers, Goldwind and Sinovel and Suzlon, an Indian manufacturer, presently comprise 18 percent of the global supply.

In hydro-electricity, the top producers, with the exception of Brazil and Canada also feature among the top-exporters of hydro-electric equipment. However, equipment imports of top hydro-electric generating countries do not appear to be very high. While major countries that produce geothermal energy are key exporters of geothermal goods, several that deploy geothermal energy, including Iceland and New Zealand, do not figure on the list of top exporters or importers. The correlation between the top traders in ocean energy equipment and deployers of ocean energy seems to be very weak. All this appears to indicate that for hydro, geo-thermal and ocean that traded components of technologies may not be the most important items in the deployment of these technologies.

Applied tariffs on most RES products in the top trading nations are in the single digits except in the case of India. For solar technologies and components the global average tariff is around 15 percent. Major importing countries such as China have applied tariffs of about eight percent (at the time of writing) and most developed countries have low or zero tariffs. It has to be borne in mind that most RES products under consideration here are 'multiple-end use' products and that many developing countries may be applying higher tariffs as part of their industrial development strategy or possibly to attract 'tariff-jumping' investment. Most developing countries, on the whole, have higher applied tariffs than developed countries and, with the exception of China, many developing countries also have some 'tariff water' between bound and applied tariffs. Ethanol is an exception to this trend in that major importing countries such as the US have an ad-valorem tariff of 2.5 percent and more significantly a specific tariff of US$14.27 cents per litre. On the other hand, tariff-free access is granted to ethanol imports to the US from Central American and Caribbean countries as part of the Caribbean Basin Initiative (CBI) and the Central American Free Trade Agreement (CAFTA), if produced from at least 50 percent local feedstock. Up to seven percent of the US market may be supplied duty-free and containing no local feedstock. This enables wet-ethanol to be shipped from Brazil to dehydration plants in CBI countries for reprocessing and re-exported to the US from there.

What drives the market for renewable energy? Section Four identifies some of the key drivers. It also discusses policies that would be needed to stimulate trade in renewable energy equipment and products. Public policies and subsidies have played a key role. The main measures used in developed countries to stimulate renewable energy markets have been laws requiring utilities to purchase all electricity generated from renewables, laws requiring renewables to represent a certain percentage of all power generation, subsidies for investments in component manufacturing, exemptions or reductions in taxes for component manufacturers, and preferential tariffs for electricity from renewables. While supportive measures are required for the development of a renewable energy market, many of these measures are also likely to provide an unfair competitive advantage to developed country manufacturers of RES products. On the other hand, the main developing countries have traditionally relied on tariff protection and, in the case of China, localization requirements to stimulate their domestic RES industry. A lowering of tariff protection on RES goods without a reform of the subsidies affecting the trade in such goods are therefore likely to expose developing countries to subsidized competition. Thus, it is important that tariff liberalization is also accompanied by subsidy reform. A number of policies also act as important non-tariff measures. Localization measures are particularly notable in this regard. In China, for instance, localization regulations may require 70 percent of the equipment used for a renewable energy project to be sourced and built domestically. Intellectual property rights may also affect the diffusion of technologies.

The number of patents that have been registered in the renewable sector in different countries could also provide an indication of the dissemination of renewable energy technologies across borders. Patent holders usually register patents in a particular country if they want to commercially exploit the particular technology in that country. Technology transfers, however, may involve the transfer of know-how which can be protected by trade secrets or other forms of intellectual property. The difference between developed and developing countries in terms of the number of patents registered has been wide but is narrowing fast. What is more striking is the difference between groups of developing countries. A small group of emerging market economies account for nearly all the patents registered. China is particularly noteworthy for its rapid growth in the number of resident-owned patents between 1998-2008. In China, 40 percent of the sampled technology patents are locally owned, while in India it is less than 14 percent.

A 2008 CERNA study shows that fuel cells and solar energy patents account for 80 percent of the growth in global patents from 1998-2000, with wind energy a distant third. The study also shows that the export rate of climate technology inventions – measured by the share of technologies that are patented in at least two countries – is around 25 percent. Most transfer flows still occur between developed countries, although North-South flows are increasing, while flows between emerging markets are almost non-existent. Furthermore, the study reveals that imports of technologies seem to crowd out local innovations: the higher the number of imported inventions, the lower the share of contemporaneous local inventions in the set of technologies used in the recipient country.

What is the relationship between trade flows in RES goods and these market drivers? A regression analysis was conducted on the sensitivity of exports and imports of RES goods to four variables, namely tariffs on imports, the percentage of renewables in the electricity grid, and the percentage of inventions, as shown by the share of the country in global patents and subsidies provided to renewables (using a dummy variable showing the presence or absence of subsidies). The regression results show that in general, the major exporting and importing countries of RES goods are also likely to patent inventions, use a high percentage of renewables showing high deployment of renewable energy, provide subsidies and have low tariffs. However, tariffs have been found to be less significant as an explanatory variable for increased exports or imports, if compared to a composite variable comprising the share of renewables in a country's grid and subsidies. This appears to indicate that tariff reduction by itself may not generate trade in RES goods without supportive market drivers and policies such as feed-in tariffs and other forms of subsidies. Markets in developed countries have grown exponentially during the last few years in response to the subsidies provided for renewable energy consumption, tax breaks, subsidies for components and the huge volume of venture capital investment.

While subsidies are important to generate a market in renewable energy, some may serve to distort trade and create an unlevel playing field in RES technologies and goods. Such subsidies look set to increase further, as part of fiscal stimulus packages, given the economic crisis at the time of writing and the consequent drying up of venture capital. Discussions in the WTO should, therefore, address the two pillars of the RES sector: subsidies and tariffs. However, as technology develops, other countries join in production, bringing down costs and increasing the divisibility of the supply chain. Thus, there is a logical case to be made for liberalizing trade in these components as they are likely to generate win-win solutions. Production particularly for the Chinese and Indian markets will also serve, through economies of scale involved, to bring down the costs of RES technologies and goods.

In terms of trade negotiations, it should be borne in mind that only a handful of developing countries are important players in the markets or trade in renewables which is essentially dominated by developed countries. This implies that trade negotiations in the WTO on environmental goods could involve approaches like request and offer for quick and effective results, based on the top exporters and importers. This is particularly the case where an environmental end-use may not be as significant at the HS 6-digit level, as in the case of predominantly single end-use products where a larger group of countries could participate in reducing tariffs and non-tariff barriers.

Further barriers to the dissemination of these technologies need to be identified and addressed. While patents may not pose an insurmountable barrier to the dissemination of renewable energy technologies, other forms of intellectual property (IP) protection, such as trade secrets, may be important to consider. Patents have been seen to correlate positively with trade in renewable energy components. Many other non-technological and more economic factors many hinder achieving carbon abatement objectives of developing countries. These include insufficient technical knowledge and absorption capacity to produce these innovative technologies locally, insufficient market size to justify local production units, and insufficient purchasing power and financial resources to acquire the innovative products. Each of these factors deserves considerable discussion. Solutions, if needed, should be sought in policies that aim to overcome these insufficiencies. Creating the right enabling environment for the market drivers of renewable energy in developing countries should, therefore, be a key deliverable of the climate negotiations ongoing at the UNFCCC and a necessary complement to any trade liberalization initiative on climate-friendly environmental goods and services (EGS) at the WTO.

1. INTRODUCTION

Background

The relationship between trade-induced economic activity and climate change is a challenging one because most economic activity generates carbon dioxide and other greenhouse gases (GHGs) which could impact climate change. At a time when the world is gripped in the worst economic crisis in 75 years it is imperative that expenditures on climate change mitigation and adaptation make economic sense. Although the mood on trade is increasingly protectionist, the economic crisis provides an opportunity to create a green economy. Trade is good because it generates a global culture of competition and innovation, and thereby results in improvements in goods and services that have an intrinsic monetary value far beyond the monies earned. However, it must also be noted that trade expansion could also result in carbon emissions which need to be managed effectively in order to reach the ultimate goal of sustainable development. Thus, trade itself can generate climate-friendly goods, technologies and practices.

Essentially:

1. Trade and globalization of investments have raised living standards, including in developing countries. These have translated into steadily rising environmental standards. While this relationship is likely to occur, it is not automatic. However, recent empiricism and especially the experience of rapidly growing countries show that preference for a cleaner environment is rising particularly because of rising health bills associated with higher emissions or pollution.

2. Trade also generates opportunities for technological leapfrogging leading to increased foreign investment. Regulatory processes in developed countries and pro-active developing countries can be expected to drive innovation towards cleaner technologies that could be disseminated to developing countries through open trading systems.

3. The discipline of trade liberalization also introduces a climate of improved policy making and administrative procedures. Today, globalization and liberalization is occurring in an environment in which the information revolution has introduced much greater accountability to the public, particularly in the environmental context. In the context of modern information technology, lessons from history and experiments with growth and environment can be more easily emulated and assimilated. The awareness and motivation of interested parties, particularly non-governmental organisation (NGOs), is much higher, and the precedence for learning successful policy lessons is much easier to emulate than in the past.

An urgent challenge is to "green" trade and economic growth driven by technological change. At the national level this would mean shifting to cleaner versions of current technology and ultimately to forms of technology that break the link between energy use and GHG emissions altogether; the energy-supply sector is crucial to this process. In this paper, the energy supply sector refers essentially to the components and equipment used to generate renewable energy. Therefore, it also includes the embedded technologies in these products. Thus, the research on energy supply should focus on encouraging dissemination of technologies and products for renewable energy. Barriers to the distribution of energy supply products and technologies also need to be addressed urgently.

The alignment of climate change policies and trade takes place within the existing paradigm of globalization, which is based on the pillars of trade and investment. Increasing liberalization in both these areas has led to greater specialization and to supply chains that cut across national boundaries.

For example, the components of a product may be made in one country, assembled in another, branded in a third country and sold to a fourth country. This kind of specialization necessarily leads to the transfer of practices, standards, products and technologies across borders, which collectively constitute the existing paradigm of globalization. Currently, the focus of the climate change and trade discourse is on competitiveness concerns, which could lead to the imposition of barriers to trade, or at least to some reversal of the current open trading regimes.

This paper argues that attention should shift from competitiveness concerns to those aspects of the trade and climate change debate which would help innovate and disseminate climate-friendly technologies. At both the international and domestic levels, the dissemination of technologies and ultimately climate-friendly products would first and foremost need openness in investment and in trade in climate- friendly goods and services.[1] At the domestic level, trade openness could be achieved through the reduction of tariffs. More importantly, development of complementary policies on subsidy reform and enhanced standards for energy efficiency (EE) and incentives for renewable sources of energy would be appropriate. Tariff reductions by themselves may be insufficient to create a market for environmental goods in developing countries. It is important to create the demand for such technologies through appropriate regulatory regimes and support policies on climate change and GHG emissions.

Methodology

This paper attempts to identify a few key drivers of trade in renewable energy technologies and products relevant for climate change mitigation efforts. On the basis of Harmonized System (HS) codes, a classification system for internationally-traded products, a preliminary analysis of trade patterns and tariff barriers in these goods was undertaken and the results are presented below.

This paper builds on a 2008 mapping study commissioned by the ICTSD and prepared by the Energy Research Centre of the Netherlands (ECN).The objective of the mapping study was to identify key climate-mitigation technologies and associated goods relevant to the renewable energy supply sector. This is a sector that has been identified by the Intergovernmental Panel on Climate Change (IPCC) as one of the critical sectors for mitigation of greenhouse gas emissions. The renewable energy technologies that are covered in the mapping study include: solar energy; wind energy; ocean energy; geo-thermal energy; hydro power and biomass.

For the purposes of further analysis, the mapping study identifies two broad categories of goods/technologies. The first is a set of technologies/goods that is available for commercial purchase and use, and the second is a range of technologies still under development but for which a strong likelihood of commercial deployment is foreseen in the near to medium-term (i.e. 5-10 years) future. The mapping study was also peer-reviewed by the IPCC IVth Assessment Report's Working Group III coordinating lead authors (Energy Supply Chapter).

The commercially available key technologies and associated goods identified were then placed, as far as possible, within 6-digit HS codes. This is because common HS codes for all products and for almost all countries are available only at the 6-digit level. Some countries or regions use more detailed HS codes (e.g. 8 or 10 digits) to specify a greater level of product detail, but the corresponding codes and product descriptions differ across countries or regions. The technologies, sub-categories and main components listed in Annex B of the ECN mapping study were placed within 83 6-digit HS codes.

On the basis of the identified 6-digit HS-codes, a preliminary analysis of trade patterns and tariff barriers in these goods was undertaken and the results are presented below. In the future, the ICTSD intends to undertake similar mapping studies and trade analyses for the buildings and transport sectors. It should also be noted that analyzing international trade in specific technologies/products and their components on the basis of HS-codes has serious limitations. As common HS numbers for products exist only up to the 6-digit level, comparing and analyzing international trade flows can only be done at rather aggregated levels. However, in this process many goods that are not related to renewable-energy generation get included. For example, the 6-digit level classification for "other gas turbines" (HS 841181) includes gas turbines that may be used in connection with gas generated from biomass and gas turbines used in airplanes.[2] In some cases a consideration of more detailed national or regional (EU) classifications may help to better understand the implications of using common 6-digit HS statistics (Annex 1 and 2).

Furthermore, generating and analyzing statistics on trade in components will generally be difficult as the same component may be used in many different end-use sectors, many of which may not be environmental as shown above in the case of gas turbines. In most cases, expert opinions and industry surveys would be needed to assess the extent to which actual and future trade in components could be assumed to be driven to a reasonable extent by demand generated by the deployment of renewable energy technology (RET).

An attempt has been made in this paper to identify, for the purposes of the analysis presented, some predominantly single-use items which are directly linked to renewable energy supply (RES) and their exports and imports. These products are ethyl alcohol (ethanol), biodiesel, photovoltaic (PV) modules, solar water heaters[3] and wind turbines. In only one case, wind turbines, is the 6-digit HS code used exclusively for the RES product in question. In other cases, 6-digit HS codes also include unrelated products. For example, in most countries biodiesel represents only a very small part of the chemical products and preparations covered by HS 382490.

Since RES products are frequently crucial for the implementation of climate-mitigation policies, in some cases national and regional European Union (EU) authorities have already taken, or are considering steps to add specific subheadings to the common 6-digit HS codes in their national or regional tariff schedules. An analysis of imports into the United States and the EU (the largest import market for RES products) at a more disaggregate level (10 and 8 digits respectively) was carried out to assess whether the results obtained from using more specific codes for RES products, rather than 6-digit HS codes, would substantially change the results, i.e. the listing of key suppliers of the RES product in question.

The trade figures shown in the tables presented in this paper have to be interpreted with extreme care.[4] These trade figures are much larger than actual trade in RES products and components. First, as mentioned above, most 6-digit HS codes that cover "single-use" products include unrelated products. Second, in the case of components, total trade under the provisions of a particular 6-digit HS code is included, although only a small part, if any, may be related to the deployment of renewable energy technologies and products. For instance, ball bearings are included because they are used in the production of wind turbines, but the table will include total trade in ball bearings for any purpose.

The rationale for including components in this paper is that trade liberalization, which makes components more easily available and cheaper, may have positive effects on the deployment of renewable energy technologies. Another justification for including components is to analyze the extent to which renewable-energy technologies may create potential market and trade opportunities for producers of components. One could argue that producers of specific components, even though they may not supply the RES sector today, could become a competitive supplier of the RES sector in the future. However, trade figures corresponding to components shown in this paper should not be presented or read as "trade in renewable-energy supply products", but rather as trade in components that may, at least in part, be exposed to developments in the RES sector. In some cases, where HS items are defined so broadly that there is hardly any chance that the RES sector is a significant driver of trade, these HS numbers were excluded from the analysis (Annex 1). For analytical purposes, a few 6-digit HS codes have been added to the ECN list. The trade analysis presented in this paper is based on 69 6-digit HS codes (Table A1.2).

The ECN list includes technologies and components that are specifically used for renewable energy supply and components that are used in connection with renewable energy supply; they may also have other applications. For example, in the case of wind energy, the list includes wind turbines, technologies specifically used for wind-energy supply (e.g. wind-turbine blades and wind towers) and components that may also be used in other applications (such as gearboxes, ball bearings and electronic control equipment). The "single environmental end-use" items identified in this paper belong to three sectors: solar, wind and bio-mass energy. The hydro-power sector does not have its "own" HS codes, but several studies include hydraulic turbines as environmental goods that are specifically relevant for this sector. In the case of ocean and geothermal energy, however, the ECN list consists entirely of a number of components of rather general use. Tables showing aggregated trade for HS items included in the ECN list for the hydro, geothermal and ocean energy sectors are shown in Annex 3. A more detailed description of the methodology, including further analyses of some implications of the use of 6-digit HS codes for analysing trade in renewable energy supply (RES) products, is given in Annex 2.

Unless otherwise mentioned, the trade figures shown in this paper include intra-EU trade (27 Member States). The group of "developing countries" include countries in Eurasia, listed as "countries in transition in Asia" (Armenia, Azerbaijan, Georgia, Kazakhstan, Kirghizstan, Tajikistan, Turkmenistan and Uzbekistan) in the United Nations Conference on Trade and Development (UNCTAD) Handbook of Statistics 2006.

Structure of the Paper

The objective of this paper is to analyse trade flows and market drivers for renewable energy technology components and equipment. In the process of identifying these market drivers the paper also reasons that policy driven market drivers are of great importance. Policies for creating renewable energy markets may influence trade and some of these policies may actually distort the conditions of trade. The paper suggests some options in order to level the playing field. Section I provides background on the relationship between trade-induced economic activity and climate change. Section II analyses global trends in the renewable energy supply sector. It sketches the main actors in the sector, the main producers and the participation of developing countries in production and trade. Section III analyzes the top traders of equipment and components used in the RES sector. It also examines tariffs in this sector. Section IV identifies the main drivers of trade in renewable energy equipment and components. In this process it also identifies the policies that would be needed to stimulate trade in renewable energy equipment and products. It also illustrates that a certain degree of equity is required for levelling the playing field in the market for renewable energy products, equipment and components. In Section V the paper concludes with suggestions for negotiations on the trade and climate change fronts. The trade analysis in this paper focuses on the issues that are relevant for negotiations on environmental goods and services (EGS) in the WTO; suggestions on creating markets and an enabling environment for renewable energy generation are relevant for climate change negotiations.

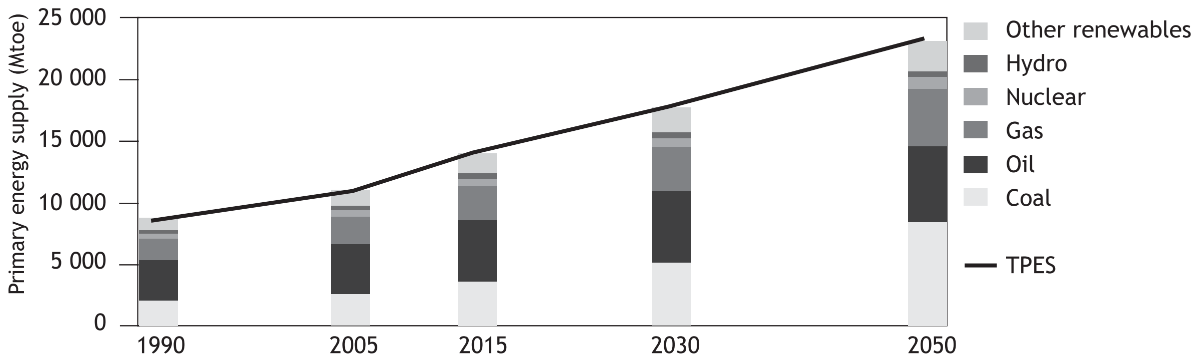
2. TRENDS IN THE RENEWABLE ENERGY SUPPLY SECTOR

This section examines the production and trade in renewable energy with a view to identifying market drivers. Only about six percent of global energy is supplied by renewables (Butler, 2006). See Figure 1 below. However, "some 50 countries have set renewable energy targets, including developing countries such as Argentina, Brazil, China, the Dominican Republic, India, Iran, Mexico, Morocco, the Philippines, Tunisia, Senegal, South Africa, Syria and Uganda. These targets vary from 5 to 20 percent of the total energy usage. The EU has set a target of generating 20 percent of its energy needs from renewables by 2030" (UNEP, 2009).

Globally some 300,000 people are employed in wind power and approximately 170,000 in solar photovoltaics. Over 600,000 people, mostly in China, are employed in solar thermal energy, while around 1.2 million people are employed in biomass energy in Brazil, China, Germany and the United States. Overall 2.3 million are employed in the renewable energy sector as a whole, which is according to the United Nations Environment Program (UNEP) a conservative figure" (UNEP, 2009).

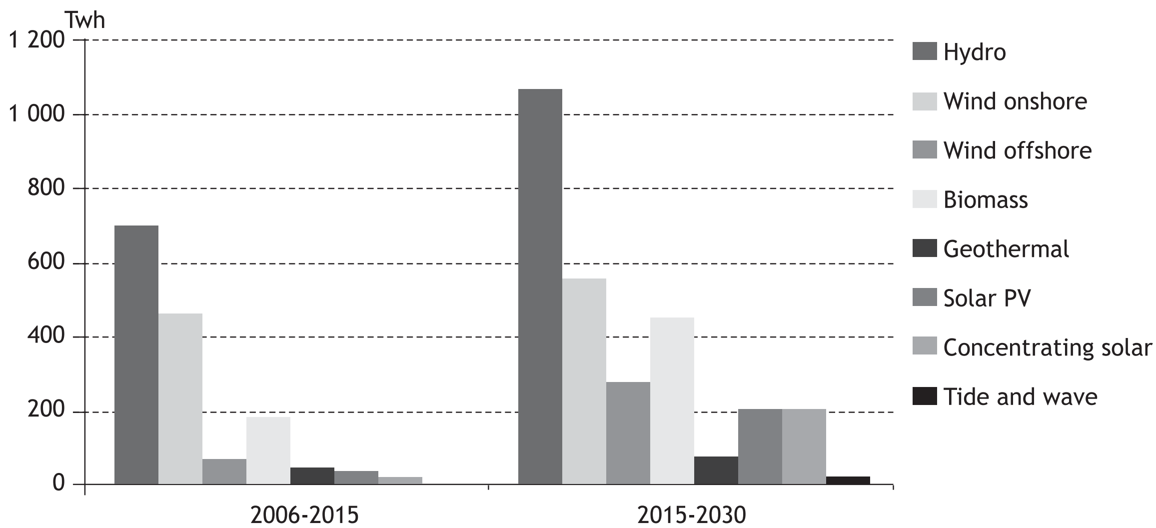
Fig. 1: Energy Supply and Electricty Generation: Present and Projected Share by Fuel Type

Fig. 1(a) World Total Energy Supply by Fuel in the Baseline Scenario



Source: IEA (2008), Energy Technology Perspectives 2008, OECD/IEA.

Fig. 1 (b) Increase in World Electricty Generation From Renewables in the Reference Scenario



Source: IEA (2008), World Energy Outlook 2008, OECD/IEA.

In developed countries, different energy supply sectors exhibit dominance within particular countries and regions. Most trade in renewable energy technologies is between developed countries, though at the six-digit level in the HS classification system there is little difference in numbering between the leading traders of manufactured products and the leading traders of energy supply technologies and products. This is because each technology is made up of a number of component parts which are freely traded. However, trade in renewable energy technologies also requires transmitting the knowledge component of those technologies, which is often embedded in the assembly and in project execution. Thus, liberalizing trade in components which are assembled to form renewable energy technologies would only be a partial step towards increasing the dissemination of renewable energy technologies. A more holistic solution would also include a more integrated package of measures and entail transferring the knowledge associated with these technologies.

Box 1: Clarifying Some Links

This paper seeks to establish correlation between production and export capacity in renewable energy. Therefore, it is necessary to clarify some links.

The first link is between renewable energy generation and trade in renewable energy technologies and components. The deployment of renewable energy technologies can influence trade in different ways. First, it can be correlated with exports. For example, Denmark, a world leader in wind-energy technology development is also a leader in exports. According to the Danish Wind Industry Association, exports of wind turbine technology worth € 5.7 billion in 2008 contributed 7.2 percent of total Danish exports. China and Germany have a large capacity to export solar panels and Brazil has a large capacity to export bio-ethanol.

However, the deployment of renewable energy technologies can also be correlated with imports. Countries installing or expanding renewable energy capacity may experience an increase in imports of renewable energy products and components. For example, nine of the 10 countries that expanded their wind energy capacity the most in 2008 (Table 13) are also included in the list of top importers of wind turbines (Table 15). The only exception is India, perhaps because it already has a long tradition in wind energy. The United States, which has witnessed strong growth in installed wind energy capacity is by far the largest import market for wind turbines, representing two-thirds of world import (excluding intra-EU trade) of wind turbines in 2007 (Table 15). A United States International Trade Commission (USITC) study found that from 1998 to 2005 changes in wind-powered generating set imports were closely correlated with changes in wind turbine installations. However, that correlation may have subsequently weakened, perhaps because a rise in domestic manufacturing led to a reduction in imports (USITC, 2009).

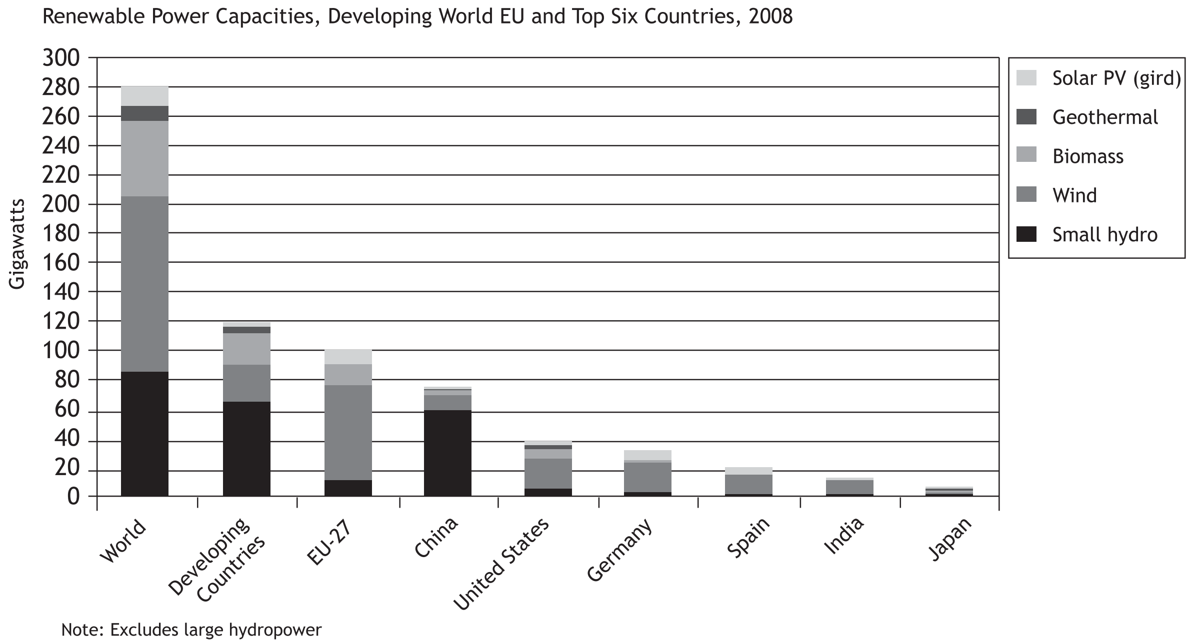
The second link is between exporting companies and exporting countries. This paper lists top companies in different sources of renewable energy, in particular solar and wind energy (together with an indication of the country where the company has its headquarters). However, trade figures shown are for countries rather than companies. To the extent that companies would serve export markets entirely from their home base, this would not create a problem. However, Original Equipment Manufacturers (OEM) may have production facilities in and export from several countries. Decisions about whether to export or establish local production facilities in target markets may be based on factors such as the proximity of the market to existing plants, transportation costs, comparative labour and production costs, the local supply base, exchange rates, import tariffs and barriers, and the size and

Box 1. ***Continued***

stability of the market (USITC, 2009). Wind turbine manufacturers, for example, often prefer to establish overseas production facilities since there are high transportation costs and logistical challenges associated with exporting nacelles, blades and towers. According to a recent survey of turbine manufacturers, more than 40 percent of companies polled indicated that the best way to enter new markets is through a subsidiary. Another 40 percent indicated that the best way is through joint ventures, while only around 10 percent prefer to service the foreign market exclusively by exporting wind technologies (HUSUM WindEnergy, 2008).

In some cases, exports are driven by factors that are largely unrelated to the deployment of renewable energy capacity in the exporting country, such as preferential access to export markets. For example, some Central American and Caribbean countries are among the top 20 exporters of bio-ethanol (Table 18) because the US import regime allows them, within certain limits, to import "wet" bio-ethanol from Brazil and Europe and export dehydrated ethanol to the US market (See Section on Biomass). There are other cases where exports represent very little value added.

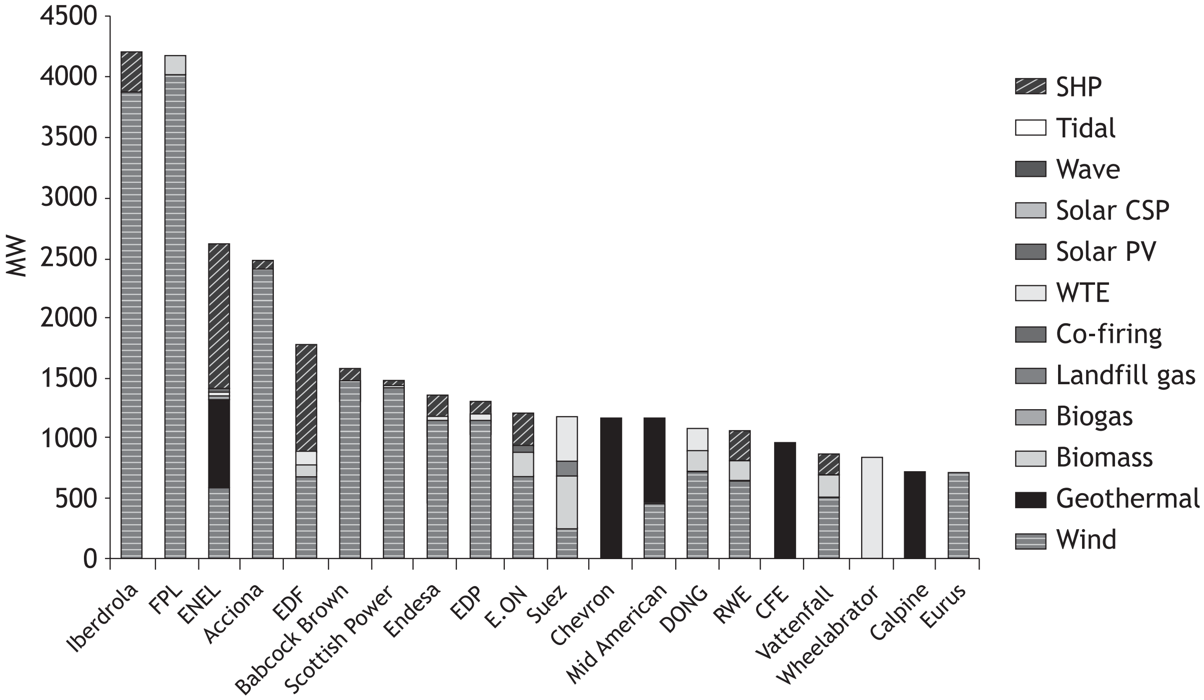
Figure 2: Distribution of Renewable Energy in 2008



Source: REN21. 2009. Renewables Global Status Report: 2009 Update (Paris: REN21 Secretariat).

"The Spanish utility Iberdrola and FPL Energy, a subsidiary of the U.S. utility FPL Group, are leading generators of renewable energy, according to rankings from Emerging Energy Research" (EER) (EER, 2007).

Figure 3: Global Renewable Power Generation Ranking 2006, Excluding Large Hydro



*Source: Emerging Energy Research **Note: (Small hydro represents projects with a capacity of less than 10 MW).*

Excluding large hydro-electric stations, wind energy dominated the installed capacity of renewables from 2001 to 2006 representing 67 percent of the combined total capacity owned by the top 20 renewable producers. After wind energy, geothermal energy represents the second largest generation technology with 13 percent of generation capacity exclusive of large hydro-electric stations. In the coming years, concentrated solar power (CSP) is likely to become very important, with 5.8 GW already in the global pipeline (EER, 2007).

Trade in Products and Components that May be Used in the RES Sector

Exports of most RES products and components are largely dominated by European companies, in keeping with the dominance of European firms in the production of renewable energy. Based on an analysis of trade flows at the 6-digit level, it appears that intra-European trade in RES is among the highest in the world.

Developing country exporters (including China which accounted for over 40 percent of total developing country exports of RES products and components that may be used in the RES sector) accounted for less than 30 percent of global exports of RES products in 2007 (Table 1). Even with intra-EU trade excluded from total world exports, the developing country share was only around 40 percent. As far as imports of RES are concerned, developing countries accounted for a slightly larger share (38 percent) of world trade (Table 2). If however, for purposes of this analysis we use single-use or primarily single-use products, the ranking of exporting countries is as indicated in Table 3. Similarly, if we use single-use or primarily single-use products the ranking of importing countries is as indicated in Table 4.

Table 1: Exports of RES Products and Components that May be Used in the RES Sector, 2007

Exporter (all)	Exports (US million)	Exporter (developing countries*)	Exports (US million)
All countries	240238	Developing countries*	67535
Germany	34587	China	28378
China	28378	Korea, Rep.	6245
Japan	23511	Taiwan, China	5825
United States	22072	Mexico	4606
France	12265	Singapore	4282
Italy	12197	Thailand	3411
United Kingdom	7264	Brazil	3252
Netherlands	7040	Malaysia	2949
Belgium	6283	India	2321
Korea, Rep.	6245	Turkey	1416
Taiwan, China	5825	Philippines	971
Sweden	5240	South Africa	718
Denmark	5220	Viet Nam	590
Mexico	4606	Argentina	443
Spain	4567	Saudi Arabia	264
Singapore	4282	Tunisia	195
Austria	4192	Colombia	173
Switzerland	3693	Pakistan	160
Thailand	3411	El Salvador	145
Canada	3325	Kazakhstan	136
EU-27	116054		
Intra-EU-27	70211		
EU-27 (excl intra-EU)	45843		

** Includes countries in Eurasia. Source: COMTRADE, using WITS*

Table 2: Imports of RES Products and Components that May be Used in the RES Sector, 2007

Importer (all)	Imports (US million)	Importer (developing countries*)	Imports (US million)
All countries	248080	Developing countries*	95720
United States	30430	China	21179
Germany	22203	Hong Kong, China	8843
China	21179	Korea, Rep.	8667
Spain	8923	Mexico	7016
France	8879	Taiwan, China	5575
Hong Kong, China	8843	Singapore	4541
Korea, Rep.	8667	Saudi Arabia	3553
Japan	8513	Thailand	3438
Italy	8225	India	3434
United Kingdom	7754	Malaysia	2689
Mexico	7016	Brazil	2519

Table 2. ***Continued***

Importer (all)	Imports (US million)	Importer (developing countries*)	Imports (US million)
Mexico	7016	Brazil	2519
Netherlands	6805	United Arab Emirates	2482
Canada	6638	Viet Nam	2280
Taiwan, China	5575	Turkey	2155
Belgium	5207	South Africa	1365
Singapore	4541	Qatar	1220
Russian Federation	4384	Kuwait	1206
Saudi Arabia	3553	Argentina	1102
Sweden	3542	Nigeria	1056
Thailand	3438	Kazakhstan	965
EU-27	92249		
Intra-EU-27	61560		
EU-27 (excl intra-EU)	30689		

** Includes countries in Eurasia. Source: COMTRADE using WITS*

Table 3: Exports of Single–use Renewable Energy Technologies in 2007

Exporter (all)	Exports (US million)	Exporter (developing countries*)	Exports (US million)
All countries	64716.9	Developing countries	18008.3
Germany	10410.8	China	6539.9
Japan	8973.5	Taiwan, China	3148.7
China	6539.9	Brazil	1549.6
United States	5250.0	Malaysia	1541.2
Netherlands	3330.4	Korea, Rep.	1254.8
Taiwan, China	3148.7	Singapore	761.8
Ireland	2561.0	Mexico	645.1
France	2371.5	India	625.9
Belgium	2101.7	Thailand	420.5
United Kingdom	2065.0	South Africa	278.1
Denmark	2030.8	Argentina	196.7
Italy	1590.7	Viet Nam	150.4
Brazil	1549.6	Pakistan	150.4
Malaysia	1541.2	El Salvador	142.3
Korea, Rep.	1254.8	Turkey	72.7
Spain	1098.4	Philippines	64.8
Austria	835.9	Jamaica	60.3
Singapore	761.8	Hong Kong, China	53.3
Mexico	645.1	Saudi Arabia	46.0
India	625.9	Guatemala	41.9

Table 3. ***Continued***

Exporter (all)	Exports (US million)	Exporter (developing countries*)	Exports (US million)
EU-27	30717.7		
Intra EU	21594.8		
EU (excl intra EU)	9122.8		

** Includes countries in Eurasia. Source: COMTRADE using WITS*

Table 4: Imports of Single–use Renewable Energy Technologies in 2007

Importer (all)	Imports (US million)	Importer (developing countries)	Imports (US million)
All countries	66632.7	All developing countries*	22073.3
Germany	8531.6	China	6511.1
United States	7753.4	Korea, Rep.	3316.9
China	6511.1	Taiwan, China	2508.6
Spain	4454.6	Hong Kong, China	2286.0
Korea, Rep.	3316.9	Mexico	1196.2
France	2533.6	Thailand	793.1
Taiwan, China	2508.6	Singapore	787.5
Netherlands	2483.0	Malaysia	572.5
Italy	2468.7	Turkey	569.9
Japan	2359.2	Brazil	415.8
Hong Kong, China	2286.0	India	395.9
United Kingdom	2231.7	South Africa	279.9
Belgium	2018.8	United Arab Emirates	197.9
Canada	1459.7	Argentina	186.3
Mexico	1196.2	Saudi Arabia	186.2
Austria	883.6	Colombia	162.1
Sweden	841.4	El Salvador	140.5
Thailand	793.1	Chile	140.5
Singapore	787.5	Viet Nam	137.4
Switzerland	681.4	Trinidad and Tobago	110.8
EU-27 total	30632.1		
Intra-EU trade	19035.7		
EU-total (excl intra-EU trade)	11596.4		

** Includes countries in Eurasia. Source: COMTRADE using WITS. For a complete description of methodology, see Annex 2.*

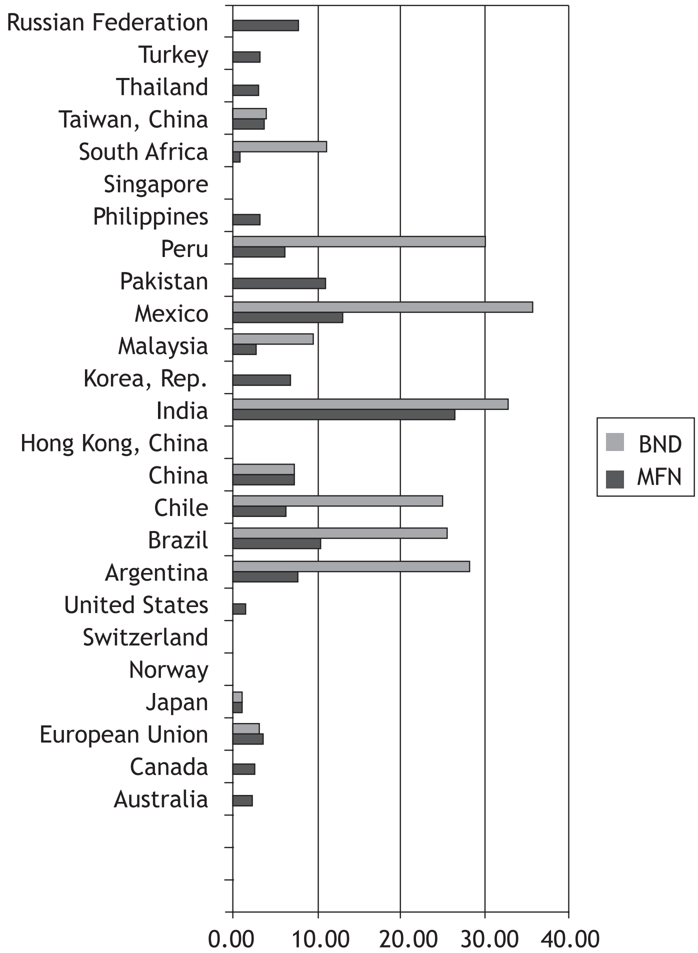
The countries which are major traders of single-use products (Tables 3 and 4) also figure as major traders in the larger list of products which include components that are relevant, although not exclusive to the renewable energy sector (Tables 1 and 2).[5] However, the relatively high share of solar panels and biodiesel in developing country exports has somewhat changed the ranking of developing countries.

The most prominent developing countries in the RES sector include China in almost all forms of renewable energy goods, especially in solar energy. Other countries and territories with a high volume of RES especially in wind and solar include India, Mexico, Hong Kong, the Republic of Korea, Malaysia, South Africa, Singapore, and Thailand. Brazil has a major role in (bio-ethanol), but also produces wind energy components. On the whole, developing countries have little capacity to trade these goods in comparison with developed countries, although Brazil has an enormous capacity to supply ethanol. This is because most of the producers are located in developed countries and intra-developed country trade is encouraged by high feed-in tariffs provided by their governments. Consequently, demand for renewable energy is stimulated in developed countries. Developing countries generally do not have such incentives and thus demand is low. This shows that there is tremendous potential for increasing trade in the renewable energy supply sector through market creation with the right incentives and a level playing field.

Tariffs

Applied tariffs for all countries except India are more or less in the single digit range. Developing countries apply higher tariffs than developed countries, but a number of products which are covered here are multiple-use products. This explains in part the higher tariffs of the developing countries which use them as part of their industrial strategies. Some developing countries may also be using tariffs as a revenue base. Given the financial and, in many countries, fiscal crisis, reducing tariffs may not be a viable option at this time shows that only reducing tariffs. Furthermore, the analysis below shows that reducing tariffs in these products is unlikely to boost demand substantially for renewables (See Section 3 and 4).

Figure 4: Tariffs on Renewable Energy Technologies, Equipment and Components



Source: WTO databases, using WITS.

Tariffs on RES in the top trading nations are generally below 10 percent (Figure 4). However, emerging economies apart from China have higher tariffs and some 'tariff water' (or difference) between bound and applied tariffs. Bound tariffs are generally higher than applied tariffs.[6] Two reasons could be advanced to explain this: Firstly, the emerging economies may have used high tariffs to attract tariff-jumping investment in renewables or justified the tariffs on the basis of an infant industry argument. Tariff walls protect nascent industries and encourage foreign direct investment for the domestic market, if the domestic market is large. Secondly, the products are of such multiple-use that tariff policy for renewables may form part of a wider industrial strategy used by emerging economies. This implies that tariff protection is being accorded to core industries which produce products that have multiple end uses in other industries. In this case, a reduction in tariffs may tilt the playing field in favour of developed countries that use subsidies to maintain and develop their competitiveness. The use of subsidies show that renewable energy generation with present technologies are not competitive vis-à-vis fossil fuels, but need the support of subsidies to be able to deliver the service to the final consumer at a competitive price. Furthermore, the development of renewables has often relied on subsidizing component manufacturers or localization clauses to develop a reliable component base. This is particularly the case for wind energy (USITC 2009). Developing countries which do not use subsidies depend on tariff protection to be able to produce for their own markets. Thus, a situation which requires them to reduce tariffs, while the developed countries continue to give subsidies to producers and consumers of renewables would expose developing countries to unfair competition.

3. TRADE AND PRODUCTION OF SPECIFIC RENEWABLES

Solar Energy

The PV industry faces an oversupply situation which is leading to falling prices along the supply chain by at least 20 to 40 percent. Furthermore, the global PV market in 2009 is likely to decrease by around 10 percent in value terms compared with 2008 (SolarPlaza, 2008).

While only one Chinese firm featured among the top 20 producers of renewable energy in 2007, emerging economies feature more prominently among the top 20 solar energy firms. However, China is emerging as the country with the most investment in PV and also has a substantial share of global trade. The fact that major consumers, in particular Spain, are not always major producers shows that solar energy components may be tradable. China's high share in trade in PV (shown below) is also indicative of the fact that several components of solar technology have now become tradable.

Table 5: Top 20 Solar Energy Firms for Photovoltaics (PV)

Rank	Company	Country of origin	Cell Technology	Capacity 2008 (Megawatts-MW) (Announced)
1	Sharp Electronics	Japan	Crystalline (1)	870
2	Q-Cells	Germany	Crystalline (1)	834
3	Suntech Power Holdings Ltd	China	Crystalline (1)	590
4	First Solar	USA	Thin-Film	484
5	SolarWorld	Germany	Crystalline	460
6	Sanyo	Japan	Crystalline	365
7	BP Solar	UK	Crystalline	480
8	Kyocera	Japan	Crystalline	300
9	Motech Industries Inc.	Taiwan	Crystalline	330
10	Solarfun Power Holdings	China	Crystalline	360
11	SunPower Corp	USA	Crystalline	414
12	Gintech Energy Corp	Taiwan	Crystalline	300
13	E-TON SOLAR TECH	Taiwan	Crystalline	320
14	Yingli Green Energy	China	Crystalline	400
15	CEEG Nanjing PV Tech Co. Ltd	China	Crystalline	390
16	China Sunergy Co. Ltd	China	Crystalline	320
17	Mitsubishi	Japan	Crystalline (1)	280
18	Ersol Solar Energy AG	Germany	Crystalline	220
19	Jing Ao Solar Co Ltd.	China	Crystalline	175
20	Moser Baer Photovoltaic	India	Crystalline (1)	120

(1) Plants that produce mostly crystalline, but also thin-film.

Source: Electronic Design Strategy News (EDN) Power Technology, September 2008.

The growth of the Chinese PV industry in 2008 can be traced to the demand generated by Spain and Germany in particular. Indeed, Chinese exports of solar panels (HS 854140) jumped from US$5.3 billion in 2007 (Table 8) to US$11.7 billion in 2008 with exports to Spain and Germany together accounting for almost 70 per cent of this increase (based on COMTRADE data). Similarly, EU import statistics show that Spain's imports of PV devices (CN 85414090) from China in 2008 amounted to Euros 2.8 billion, a 240 increase over 2007. However, developments in the Spanish and German PV markets coupled with the economic crisis which led to declining global demand at the end of 2008 is likely to lead to a decrease in exports from China in 2009. In Spain, after growing by more than 2600 Megawatts (MW) of new installed solar power in 2008, the size of the PV market will shrink considerably in 2009. This is because installed capacity that is eligible for incentives provided through feed-in tariffs is capped to 500 MW in 2009, implying that the size of the PV market may be 2100 MW (80 percent) lower than in 2008. In Germany, a reduction of feed-in tariffs is also expected to adversely affect the PV market. Reports show that many of the hundreds of PV module manufacturers have already gone out of business (SolarPlaza, 2009).

The growth point in Europe is likely to shift to Italy which has some of the most attractive feed-in tariffs. In terms of size, Italy's demand may be smaller than Spain's in 2009, but it may well become the second largest market in the world in 2010. Promising new markets are also likely to emerge in Belgium, the Czech Republic, France, Greece, India, and the Republic of Korea, all of which had less than 50 MW of installed capacity at the end of 2008. However, the growth in the Italian and other markets is unlikely to compensate for the reduction in solar installation in Spain in 2009 (2100 MW). As in Spain, even under the most attractive circumstances, it takes at least three years to achieve a market size in the hundreds of MW. As a result, and based on its global market demand model, SolarPlaza expects the global PV market to decline in 2009 (Solarplaza, 2009).

Table 6: Top 20 Exporters of Solar Energy Technologies and Components, 2007

Exporter (all)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
All countries	93400.6	Developing countries	34615.7
China	17589.5	China	17589.5
Germany	12573.6	Taiwan, China	4254.1
Japan	10806.1	Korea, Rep.	3258.7
United States	8327.5	Thailand	2351.7
Taiwan, China	4254.1	Singapore	1681.1
Italy	3608.1	Malaysia	1558.5
Korea, Rep.	3258.7	Mexico	1328.9
France	3035.7	Philippines	915.1
United Kingdom	2459.1	India	859.2
Thailand	2351.7	South Africa	183.5
Sweden	2301.7	Brazil	173.9
Netherlands	2193.8	Turkey	157.0
Switzerland	1956.6	Saudi Arabia	69.7
Belgium	1791.9	Viet Nam	60.2
Singapore	1681.1	Argentina	43.8
Malaysia	1558.5	Hong Kong, China	30.9
Austria	1485.6	Costa Rica	13.3
Mexico	1328.9	Macao	9.2

Table 6. *Continued*

Exporter (all)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
Finland	1176.6	Tunisia	8.8
Czech Republic	1124.3	Ghana	6.7
EU-27	35617.4		
Intra-EU-27	21274.9		
EU-27 (excl intra-EU)	14342.5		

** Includes countries in Eurasia. Source: COMTRADE using WITS.*

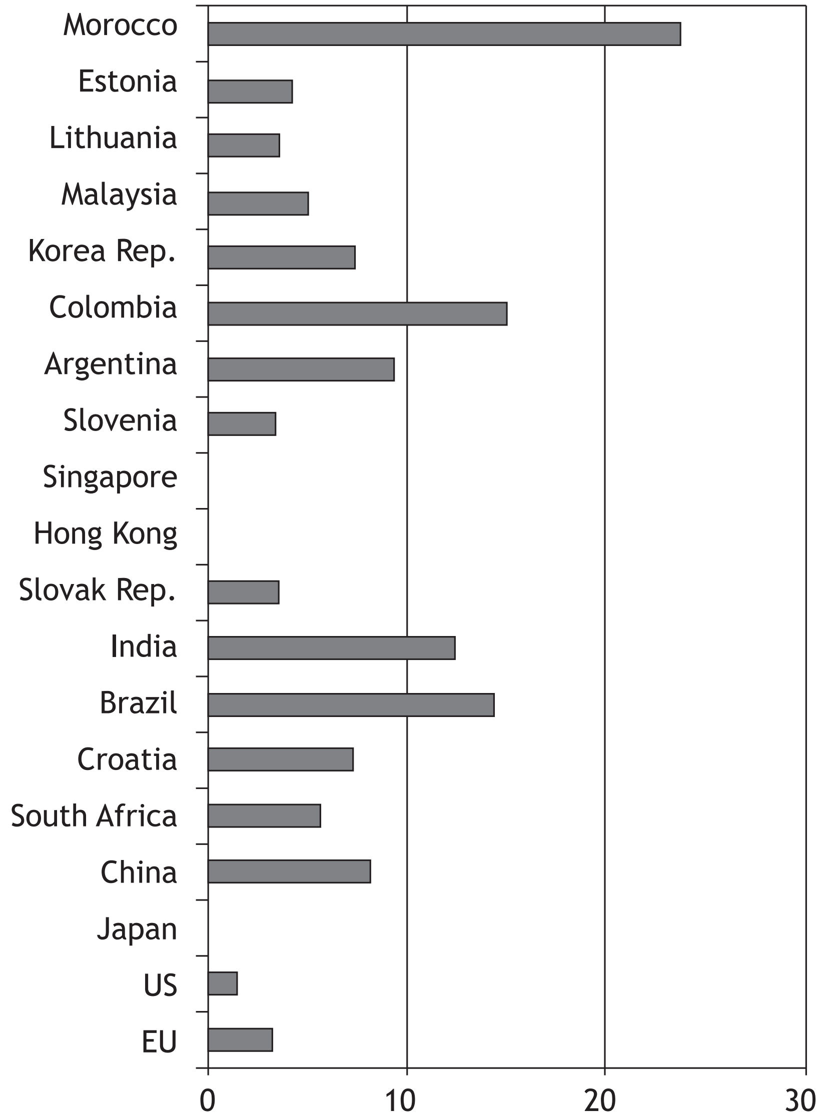
The major importers of solar energy products are not necessarily the biggest producers in terms of installed capacity, which suggests two factors. The first is that these imports may consist of several multiple-use products, or that major parts of the solar industry are not traded. In fact, the single end-use list for solar energy (Table 8) shows very few traded products. Another factor is that countries like China may produce these products for exports, but may consider them too expensive to deploy locally.

Table 7: Top 20 Importers of Solar Energy Technologies and Components, 2007

Importer (all)	Imports (US$million)	Importer (developing countries*)	Imports (US$million)
All countries	98832.9	Developing countries	39721.1
United States	12426.1	China	11015.2
China	11015.2	Hong Kong, China	5884.4
Germany	9696.2	Korea, Rep.	4369.4
Hong Kong, China	5884.4	Taiwan, China	2652.4
Japan	4507.5	Mexico	2350.5
Spain	4494.5	Singapore	1783.0
Korea, Rep.	4369.4	Thailand	1445.1
France	2868.4	Saudi Arabia	1356.1
Taiwan, China	2652.4	Malaysia	1263.3
Netherlands	2590.2	India	1048.2
Italy	2495.8	Viet Nam	798.0
Canada	2462.4	Brazil	760.4
United Kingdom	2401.6	Turkey	568.1
Mexico	2350.5	Qatar	521.2
Russian Federation	1989.6	United Arab Emirates	504.6
Singapore	1783.0	South Africa	437.5
Belgium	1551.3	Kazakhstan	332.1
Thailand	1445.1	Argentina	316.2
Saudi Arabia	1356.1	Pakistan	222.0
EU-27	34149.9		
Intra-EU-27	17103.7		
EU-27 (excl intra-EU)	17046.3		

** Includes countries in Eurasia. Source: COMTRADE using WITS.*

Figure 5: Applied Tariffs on Solar Energy Goods in Major Importing Countries



Source: WTO databases, using WITS.

Tariffs

Applied tariffs on solar technologies and components are generally below 15 percent. The global average tariff also is around 15 percent. Countries which are major importers such as China have tariffs of about 8 percent whereas the major users in the developed countries have low or zero tariffs. Thus, reducing tariffs alone may have little effect on generating a market for solar energy goods. This would especially be the case at a time when prices themselves are falling and there is global over-supply. However, tariff reductions, along with other affirmative government policies to promote this sector, could have a beneficial effect on the markets for these goods. Moreover, if tariff reductions and lower prices obviate the need for feed-in tariffs to stimulate demand, the long-term effect of tariff reduction may be beneficial to the market for solar energy.

However, there is an inherent inequity in tariff reduction. While developed countries use subsidies such as feed-in tariffs to stimulate local uptake of solar energy, developing countries may use tariff barriers to protect their industry from competition. In order to level the playing field, both tariffs and subsidies should be reduced simultaneously, or subsidies should at least be transparent and implemented in a trade-neutral manner. On the other hand, this may have an adverse impact on the market for solar energy as the market is dependent on subsidies.

Falling costs of solar modules makes solar energy increasingly attractive. The big question for the near-term is which of the solar PV manufacturers will be able to survive the global decrease in demand and the economic crisis in 2009, which could last until 2010. When the cost of solar energy declines to parity with the cost of buying energy from the grid, the market potential for a reliable, predictable and 25-year fixed-cost energy source will be enormous. It is estimated that this 'grid parity' will be reached in the next three to five years in major markets in the world. In addition, if developing countries are not able to offer subsidies such as feed-in tariffs to kick- start demand for solar energy, alternative sources of funding need to be found (Solarfuture, 2009).

Solar panels

The key single-use item identified for solar energy is PV panels, which are part of HS 854140. As shown in Tables 8 and 9, Asian developing countries play an important role in the export of PV cells and panels, representing 55 percent of world exports, if intra-EU trade is excluded.

Table 8: Top 20 Exporters of Solar Panels, 2007 (HS ex854140 Photosensitive Semiconductor Devices, Including Photovoltaic Cells Whether or not Assembled in Modules or Made up into Panels; Light–Emitting Diodes)

Exporter (all)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
World	25520.3	All developing countries*	10,808.5
Japan	5472.2	China	5,252.3
China	5252.3	Taiwan, China	2,580.0
Germany	3522.3	Malaysia	1,068.1
Taiwan, China	2580.0	Korea, Rep.	563.2
United States	1582.2	Singapore	500.3
Malaysia	1068.1	Thailand	213.6
United Kingdom	741.4	India	212.8
Korea, Rep.	563.2	Mexico	200.6
Singapore	500.3	South Africa	118.2
Belgium	492.2	Philippines	61.1
Netherlands	483.0	Hong Kong, China	12.0
Austria	359.6	Macao	9.2
Czech Republic	335.6	Viet Nam	6.8
Sweden	282.0	Oman	3.1
France	268.4	Turkey	2.0
Hungary	244.1	Brazil	1.2
Thailand	213.6	Kenya	1.0
India	212.8		
Mexico	200.6		
Spain	193.6		
EU-total	7244.5		
Intra-EU trade	5986.1		
EU-total (excl intra-EU trade)	1258.4		

** Includes countries in Eurasia. Source: COMTRADE using WITS.*

Developing countries, in particular in Asia, are also relatively large importers of PV cells and modules (Table 9). However, on balance they registered a trade surplus in 2007.

Table 9: Top 20 Importers of Solar Panels, 2007 (HS ex854140 Photosensitive Semiconductor Devices, Including Photovoltaic Cells Whether or not Assembled in Modules or Made up into Panels; Light–Emitting Diodes)

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
World	25413.4	All developing countries*	8964.9
Germany	4865.3	China	3288.6
China	3288.6	Hong Kong, China	1817.5
Spain	3208.3	Korea, Rep.	1276.8
United States	2155.7	Taiwan, China	544.4
Hong Kong, China	1817.5	Singapore	503.6
Korea, Rep.	1276.8	Mexico	442.5
Japan	1131.3	Malaysia	306.9
Italy	897.6	India	168.9
United Kingdom	619.1	Thailand	167.1
Taiwan, China	544.4	South Africa	141.1
France	528.8	Brazil	91.7
Belgium	520.6	Viet Nam	33.9
Singapore	503.6	Turkey	29.2
Mexico	442.5	Philippines	23.3
Hungary	354.5	Bangladesh	16.6
Czech Republic	319.6	Kenya	10.3
Netherlands	310.2	Algeria	8.0
Malaysia	306.9	Morocco	7.5
Austria	281.4	Argentina	7.0
Sweden	262.3	United Arab Emirates	5.6
EU-total	12627.4		
Intra-EU trade	4235.3		
EU-total (excl intra-EU trade)	8392.1		

** Includes countries in Eurasia. Source: COMTRADE using WITS .*

With regard to tariffs for single-use solar energy products, PV cells and modules enter most markets at zero Most Favored Nation (MFN) rates.[7] As shown in Annex IV, the 15 largest import markets (taking the EU as one) have zero applied tariffs on an MFN basis and all but two of these countries (Mexico and South Africa) have bound their duty-free rates. Among the 25 largest importers, only Bangladesh, Brazil and the Russian Federation provide tariff protection through applied rates.

Wind Energy

The wind energy market

Over the past three years, from 2005 to 2008, the global wind turbine market has seen explosive growth in nearly all dimensions, including the size of turbines, projects, and buyers.

Key trends highlighted in a recent Emerging Energy Research (EER, 2008) study include:

- "Intensified competition among wind turbine manufacturers has encouraged new firms while pushing leading firms to expand their sales and production globally;
- Multiple players moved to the larger turbine segments. Vestas and Enercon, pioneers in 2 MW and larger turbines, have to compete with Gamesa, Siemens, Suzlon/REpower, Alstom/Ecotecnia and others providing buyers more options;
- Turbine prices and the costs of installation increased between 2005 and 2008 after nearly a decade of cost reductions per MW. Until the economic crises of 2009, the industry had shifted from a buyer's to a seller's market, with corresponding price increases;

Component suppliers have to keep pace with turbine demand, calling for major production capacity investments in the multi-megawatt segment, as well as a focus on local supply in booming new markets while keeping costs down" (EER, 2008).

The wind industry grew 28 percent a year between 2004 and 2008 and is expected to double in terms of installed capacity about every three or four years. While the industry used to be centred in Europe, mostly in Germany, 50 countries are now actively installing turbines and employ around 100,000 people. The drivers for growth are government support, the advent of renewable energy certificates (RECs) and, mainstream financial investors and wind park developers, from Goldman Sachs to Babcock & Brown (Progressive Investor, 2009).

The global financial and economic crises may be particularly onerous for the wind power industry as investment in this sector is likely to fall. The decline in oil prices may also be a disincentive to invest in wind power.

A third of the world's wind capacity is held by the top 20 wind farm owners. The world wind turbine supply is dominated by: Vestas (34 percent), Gamesa (18 percent), Enercon (15 percent), GE Wind (11 percent), Siemens (6 percent), Suzlon (4 percent), REpower (3 percent), Mitsubishi (2 percent), Ecotècnia (2 percent) and Nordex (2 percent) (Progressive Investor, 2009). An interesting development on the supply side is that Asian manufacturers of wind turbines increased their share of the global market. Two Chinese manufacturers (Goldwind & Sinovel) and one from India (Suzlon) now provide 18 percent of the global supply (BTM Consult ApS, 2009).

The fastest growing markets for wind turbines between 2004 and 2007 were in China, France and the US. In the coming five years the highest growth in installed capacity is expected in the US and China. In fact, according to the Global Wind Energy Council (Table 13), the United States had the largest installed capacity in 2008 (Global Wind Energy Council, 2009). The installed capacity by the end of 2007 was 1 percent of the global consumption of electricity and will reach some 2.7 percent by end of 2012. China has increased its annual installation by an average of 93 percent per year since 2004. China made remarkable progress in building up its own wind industry – including the related supply chain for key-components (BTM Consult ApS, 2009).

Table 10: Top 20 Exporters of Wind Energy Technologies and Components in 2007

Exporter (all countries)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
All countries	87759	Developing countries	21981
Germany	13370	China	6764
Japan	6854	Mexico	2886
China	6764	Singapore	2105
United States	6220	Korea, Rep.	2088
Italy	5850	Brazil	1391

Table 10. ***Continued***

Exporter (all countries)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
France	4683	India	1236
Denmark	3793	Turkey	1106
Mexico	2886	Taiwan, China	983
Spain	2662	Malaysia	680
United Kingdom	2550	Thailand	634
Belgium	2301	Viet Nam	482
Singapore	2105	South Africa	363
Korea, Rep.	2088	Tunisia	180
Austria	1854	Saudi Arabia	150
Sweden	1825	Colombia	145
Netherlands	1528	Argentina	127
Canada	1393	Morocco	109
Brazil	1391	Kazakhstan	105
Finland	1291	Syrian Arab Republic	96
Poland	1288	Chile	55
EU-27	48106		
EU-27 (excl intra-EU)	19974		
Intra-EU	28132		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Trade

The top 20 exporters of wind energy components are not identical to the top 20 producers of wind energy. For example, while India and China together command nearly 20 percent of the global output in wind energy, India is not among the top 20 exporters. As mentioned earlier, there is a difference in the manufacture of wind turbines and the establishment of wind farms. While wind turbines are traded, wind farms are established in places where there is adequate government support and consumer demand. Thus, traders of components of wind technology and their assembly may actually differ. For example, suppliers of components may not be the same as the firms which assemble these turbines. However, if this were the case, then the main producers would figure as importers of these components. Indeed, this is the case for a number of countries among the top 20 importers. The top 20 global importers are those that have a well-developed wind power industry, which is usually buoyed by supportive policies such as feed-in tariffs. The outliers in this case are the developing countries like India, which are major generators but not major traders. Indian firms are also investing in backward integration. For example, Suzlon produces most of the components itself and has also acquired component manufacturers (USITC, 2009). This can, in part, be explained by the fact that most of the components are probably produced locally; hence, there is a comparatively lower volume of imports. Secondly, it exposes the limitations of the 6-digit HS classification codes for the technologies. Several multiple-use products may be included in this list, thus limiting the correlation between trade and environmental end uses.

Table 11: Top 20 Importers of Wind Energy Technologies and Components in 2007

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All countries	92543	Developing countries*	33668
United States	13797	China	5968
Germany	8362	Mexico	3509
China	5968	Hong Kong, China	2382
Mexico	3509	Singapore	2098
France	3413	Korea, Rep.	1818
Italy	3333	India	1777
Spain	3086	Saudi Arabia	1377
United Kingdom	3065	Brazil	1325
Canada	2740	United Arab Emirates	1259
Hong Kong, China	2382	Thailand	1060
Japan	2315	Taiwan, China	903
Singapore	2098	Turkey	888
Denmark	2089	Malaysia	877
Belgium	1939	South Africa	653
Korea, Rep.	1818	Viet Nam	560
India	1777	Qatar	539
Netherlands	1578	Argentina	498
Sweden	1436	Kazakhstan	430
Saudi Arabia	1377	Nigeria	428
Brazil	1325	Kuwait	378
EU-27	34960		
Intra-EU	26193		
EU-27 (excl intra-EU)	8767		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Table 12: Top Original Equipment Manufacturers (OEM) of Wind Turbines

Original Equipment Manufacturers (OEM)	Global market share (%)
Vestas (Denmark)	17.8
General Electric (United States)	16.7
Gamesa (Spain)	10.8
Enercon (Germany)	9.0
Suzlon (India)	8.1
Siemens (Germany)	6.2
Sinovel (China)	4.5
Acciona (Spain)	4.1
Goldwind (China)	3.6
Nordex (Germany)	3.4
Dongfang (China)	3.4
REpower (Germany)	3.0
Mitsubishi (Japan),	2.6
Other	6.8

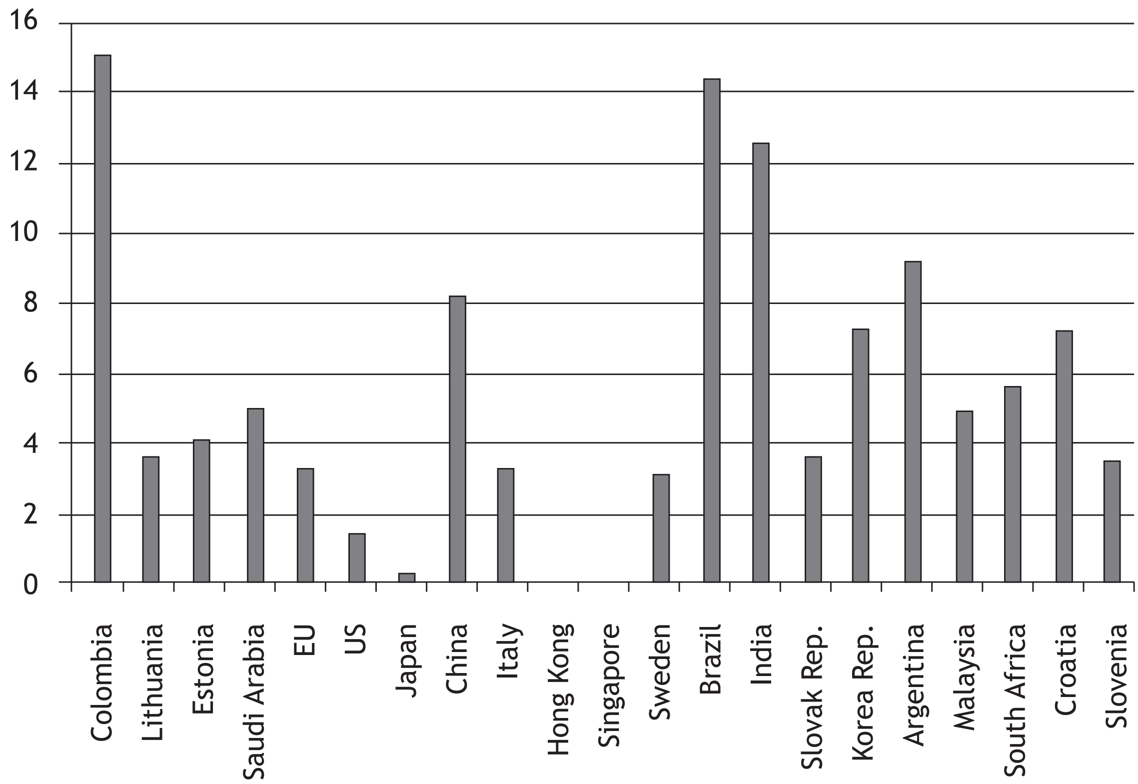
Source: BTM Consult, International Wind Energy Development: World Market Update 2008, Page 24.

Tariffs

Applied tariffs on imported wind energy products are shown in Fig 6 below. Apart from a few developing countries which apply double-digit tariffs, the rest apply single-digit tariffs.

In fact, some of the leading producers such as India do not figure among the major exporters and importers, and apply higher tariffs than developed countries. However, tariffs on wind energy products differ little from those applied to other industrial products, and thus are unlikely to have affected trade in a significant way. The development of the domestic market may critically depend on the availability of investment, both domestic and foreign, as shown above. In fact, given the large size of its market and the enabling environment provided by the government for this industry, it is possible that domestic and foreign investment may have been attracted to this industry in India (Indian Wind Energy Association, 2008). Government policies aimed at providing an enabling environment seem to have contributed more to the development of the domestic industry in India than tariff protection.

Figure 6: Applied Tariffs of Major Importers of Wind Energy Components for 2007



Source: WTO databases using WITS.

The experience of China contrasts with that of other developing countries. It is one of the leading exporters and importers of wind energy components and has low tariffs. The development of the industry is more dependent on subsidies, particularly consumption subsidies and the huge investments that flow from commercial banks. In a situation of financial crisis, tariff liberalization can facilitate investment, but government incentives will probably be needed to generate demand for wind energy.

Cross-country regressions on wind components show that feed-in tariffs positively affected imports of components in wind energy. However, the current economic climate and its accompanying stimulus packages are unlikely to be friendly to imports. Under these circumstances, arguing for a tariff reduction for these products would again tilt the playing field against developing country producers.

Wind turbines

If we examine wind turbines, the mapping of producers and their correlation to turbine exporters appears to be closer than that for wind energy components. This implies that trade in wind-powered turbines may be a more accurate indicator of end use, as countries which feature as major producers of wind energy also figure as major traders. Changing the product lines to show the correlation between production and trade also exposes the limitations of the HS classifications. While mapping the HS codes could be useful, it may not be exhaustive and multiple end uses may limit the usefulness of the mapping exercise.

Table 13: Global Installed Wind-Power Capacity (MW)

Top 10 total installed capacity by end 2008			Top 10 new capacity added in 2008		
	MW	Share (%)		MW	Share (%)
United States	25,170	20.8	United States	8,358	30.9
Germany	23,903	19.8	China	6,300	23.3
Spain	16,754	13.9	India	1,800	6.7
China	12,210	10.1	Germany	1,665	6.2
India	9,645	8.0	Spain	1,609	5.9
Italy	3,736	3.1	Italy	1,010	3.7
France	3,404	2.8	France	950	3.5
United Kingdom	3,241	2.7	United Kingdom	836	3.1
Denmark	3,180	2.6	Portugal	712	2.6
Portugal	2,862	2.4	Canada	523	1.9
Rest of the world	16,686	13.8	Rest of the world	3293	12.2
Of which:			Of which:		
- Turkey	433		- Turkey	286	
- Egypt	365		- Brazil	94	
- Taiwan, China	358		- Taiwan, China	81	
- Brazil	341		- Egypt	55	
- Korea, Rep	236		- Korea, Rep	43	
World total	120,791	100		27,056	100

Source: Global Wind Energy Council (GWEC), 2009.

Table 14: Exporters of Wind Turbines, 2007 (HS 850231 Other Generators, Wind-Powered)

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
World	3910.9	All developing countries*	524.8
Denmark	1718.6	India	335.8
Germany	969.5	Viet Nam	108.6
Japan	354.0	China	78.0
India	335.8	Brazil	1.0
Spain	198.0		
Viet Nam	108.6		
China	78.0		
Italy	44.5		

Table 14. ***Continued***

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
Australia	36.9		
Netherlands	15.8		
United Kingdom	15.2		
United States	14.2		
Greece	5.1		
France	4.4		
Czech Republic	2.2		
Canada	2.2		
Estonia	2.0		
Austria	1.4		
Brazil	1.0		
EU-total	2978.6		
Intra-EU	1118.5		
EU-total (excl intra-EU trade)	1860.2		

**Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Table 15: Importers of Wind Turbines, 2007 (HS 850231 Other Generators, Wind–Powered)

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All countries	5343.0	All developing countries	752.7
United States	2365.1	China	372.0
Germany	453.3	Taiwan, China	123.9
China	372.0	Turkey	92.4
Spain	264.9	Brazil	42.3
Italy	210.8	Thailand	37.8
Netherlands	204.4	Korea, Rep.	33.6
Australia	158.2	Mexico	17.1
Belgium	141.0	Sudan	9.0
France	131.8	Uruguay	6.9
Taiwan, China	123.9	Oman	4.1
United Kingdom	121.3	Ecuador	2.7
Canada	108.6	Argentina	2.4
Portugal	100.1	Malaysia	1.4
Turkey	92.4	Chile	1.0
Greece	68.5	Yemen	1.0
Japan	62.5	Saudi Arabia	0.9
Brazil	42.3	India	0.6
Hungary	40.8	Vanuatu	0.6
Thailand	37.8	United Arab Emirates	0.5

Table 15. ***Continued***

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
Korea, Rep.	33.6	Philippines	0.4
EU-27	1864.1		
Intra-EU	1765.9		
EU-27 (excl intra-EU)	98.2		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

However, trade in wind turbines and components is determined largely by policies in importing countries. In the United States the industry wants to localize important components of the supply chain to reduce transportation costs and logistical difficulties, avoid import duties, and mitigate the risks associated with currency fluctuations. Localization of up to 70 percent has also been reported in China (USITC, 2009). The American Recovery and Reinvestment Act (Stimulus Bill) of 2009 provides a 30 percent tax credit (called Advanced Energy Manufacturing Credits) for retooling manufacturing facilities or investing in new manufacturing plants all along the supply chain of renewable energy (ARRA, 2009). Therefore, this act provides a manufacturing subsidy for components; hence, it could be considered as affecting trade or a distortion of the playing field.

Anecdotal evidence and data for individual states indicate that expansion in nacelle, blade, and tower manufacturing has led to growth in the number of companies in the US producing materials or components for these products. For example, Clipper Windpower produced its first wind turbines in Iowa in 2006 and in 2009 had about 90 in-state suppliers. Similarly, the number of wind turbine manufacturing industry suppliers in Ohio increased from fewer than 12 in 2004 to about 37 in 2007. In 2008 there were more than 50, while in Colorado, Hexcel and Creative Foam Corp. are establishing manufacturing plants to supply the new Vestas blade plants. Thus, subsidies for the investment in such plants may discourage import of parts and components and favour local production (USITC, 2009).

Biomass

Biomass is currently the most important renewable-energy source on a global scale, which can be used for heat, electricity, liquid fuels and chemicals. Biomass sources include forest, agricultural and livestock residues, short-rotation forest plantations, dedicated herbaceous energy crops, the organic component of municipal solid waste, and other organic waste streams (Lako, 2008). Much experience already exists with commercial medium- and large-scale biomass-based combustion systems to produce power and heat and combined heat and power (CHP). Associated equipment and related components include, for example, boilers, steam turbines, gas turbines, generators and equipment for gas cleaning and for filtering. Bio-ethanol (1st generation) generation may drive demand for equipment for fermentation, distillation and purification. This paper focuses largely on trade in bio-ethanol and biodiesel (1st generation).

In this paper, trade in the group “biomass technologies and components” is estimated using 16 6-digit HS codes. The reader should be aware that HS 382490, which includes biodiesel, is by far the most important item in terms of international trade, accounting for 58 percent of world exports (including intra-EU trade) of all items in this group (Table A2.2). Ethyl alcohol (HS 2207) represents another 8 per cent. The weight of equipment and components is relatively low, the most important item being “other gas turbines, of a power exceeding 5,000 kW” (HS 841182).

Biomass technologies and components

The major exporters of biomass-based technologies and components are shown in Table 16. Most exports of some countries appear among the top 20 exporters, such as the US, Germany and Japan.

Table 16: Exporters of Biomass–Related Technologies and Components, 2007

Exporter (all)	Exports (US$million)	Exporter (developing countries*)	Exports (US$million)
All countries	48999	Developing countries*	8260
United States	7829	China	1924
Germany	7023	Brazil	1646
Japan	4664	Korea, Rep.	762
France	3369	Malaysia	647
Netherlands	3051	Taiwan, China	595
Ireland	2549	Singapore	535
United Kingdom	2402	Mexico	303
Italy	2171	Argentina	257
China	1924	Thailand	240
Belgium	1779	India	199
Brazil	1646	South Africa	183
Austria	841	Pakistan	150
Spain	837	El Salvador	143
Korea, Rep.	762	Turkey	122
Canada	711	Jamaica	60
Malaysia	647	Philippines	44
Taiwan, China	595	Guatemala	44
Sweden	547	Saudi Arabia	42
Switzerland	543	Hong Kong, China	41
Singapore	535	Viet Nam	40
EU-27	26371		
Intra-EU trade	16222		
EU-27 (excl intra-EU)	10149		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS

The major importers of biomass-based technologies and components are shown below in Table 17.

Table 17: Importers of Biomass–Related Technologies and Components, 2007

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All countries	47972	Developing countries	19631
United States	4124	China	3444
China	3444	Korea, Rep.	2303
Germany	3436	Taiwan, China	1967
Korea, Rep.	2303	Mexico	971

Table 17. ***Continued***

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
Netherlands	2185	Thailand	834
France	2067	Viet Nam	808
United Kingdom	2034	Saudi Arabia	759
Taiwan, China	1967	Singapore	694
Italy	1853	United Arab Emirates	673
Japan	1541	Turkey	648
Belgium	1512	Malaysia	496
Spain	1193	Hong Kong, China	477
Canada	1096	India	475
Mexico	971	Brazil	444
Russian Federation	965	Algeria	440
Thailand	834	Nigeria	420
Viet Nam	808	Kuwait	285
Saudi Arabia	759	Argentina	266
Singapore	694	Chile	241
United Arab Emirates	673	South Africa	217
EU-27	18699		
Intra-EU	14320		
EU-27 (excl intra-EU)	4379		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Bio-ethanol

The two largest producers of bio-ethanol, Brazil and the United States, are also among the top three exporters (Table 18). This reflects a close correlation between the major exporters and the major producers. However, the list of top 20 exporters also includes countries that are not large producers of bio-ethanol. This can be attributed to various factors, in particular US tariff preferences. This is elaborated below.

Table 18: Bio–Ethanol Exports, 2007 (HS 2207 Ethyl Alcohol)

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
World	4197.2	All developing countries*	2356.7
Brazil	1477.7	Brazil	1477.7
France	407.7	Pakistan	146.1
United States	385.1	El Salvador	142.1
Spain	171.7	South Africa	103.8
United Kingdom	166.1	China	63.2
Pakistan	146.1	Jamaica	60.1
El Salvador	142.1	Aruba	48.0
Germany	138.8	Argentina	38.3
Belgium	123.9	Guatemala	38.2

Table 18. ***Continued***

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
South Africa	103.8	Costa Rica	29.5
Canada	68.8	Bolivia	28.2
China	63.2	Trinidad and Tobago	27.8
Jamaica	60.1	Thailand	27.2
Sweden	59.1	India	17.7
Netherlands	58.5	Ecuador	15.8
Italy	56.9	Viet Nam	14.6
Aruba	48.0	Turkey	12.5
Hungary	44.5	Malaysia	11.2
Slovak Republic	43.1	Peru	9.0
Argentina	38.3	Kenya	7.8
EU-total	1353.4		
EU-total (excl intra-EU trade)	85.3		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

It is not possible to know from trade statistics at the 6-digit HS level how much of imported ethyl alcohol is used for fuel. If intra-EU trade is excluded, the Unites States appears as the world's largest importer (Table 19). From July 2008, the HTSUS includes new 10-digit codes for US imports of both undenatured and denatured ethyl alcohol for fuel use. US Imports under the provisions of these items accounted for almost 90 per cent (in value terms) of total US imports under the provisions of HS 2207 in the period July 2008-May 2009. Around one third of these were direct imports from Brazil (mostly in August and December 2008). The United States also imported ethyl alcohol for fuel use from Costa Rica, El Salvador, Jamaica, Tobago and Trinidad (see below).

Table 19: Bio–Ethanol Imports, 2007 (HS 2207 Ethyl Alcohol)

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
World	4888.1	All developing countries*	984.1
United States	1071.9	Nigeria	195.8
Netherlands	464.4	El Salvador	135.3
Germany	381.6	Korea, Rep.	119.3
Canada	330.3	Trinidad and Tobago	71.6
Japan	262.8	Aruba	54.8
United Kingdom	243.9	Jamaica	43.2
Sweden	196.2	Turkey	41.4
Nigeria	195.8	Singapore	40.1
Belgium	159.9	Colombia	31.9
France	148.2	Mexico	29.4
El Salvador	135.3	Taiwan, China	28.3

Table 19. ***Continued***

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
Korea, Rep.	119.3	Ghana	22.2
Italy	110.7	Chile	20.0
Spain	83.2	Malaysia	15.0
Trinidad and Tobago	71.6	India	12.8
Austria	59.4	United Arab Emirates	12.3
Poland	49.7	Philippines	9.1
Denmark	46.8	Thailand	8.8
Hungary	44.5	Uganda	8.7
EU-total	2172.9		
Intra-EU trade	1615.0		
EU-total (excl intra-EU trade)	557.9		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

The appearance of several countries in Central America and the Caribbean countries among the top 20 exporters and top 20 importers can be largely explained by their preferential access to the US market. The following two paragraphs draw heavily on Yacobucci's report to the US Congress, 2008.

US fuel ethanol consumption has grown significantly in the past several years. It is expected that it will continue to grow with the establishment of a renewable fuel standard (RFS) which requires US transportation fuels to contain a minimum amount of renewable fuel, including ethanol.[8] Most of the US market is supplied by domestic refiners producing ethanol from American corn. Imports play a small, although growing, role in the US market. One reason is a 2.5 percent ad valorem tariff and, more significantly, a tariff of US$14.27 cents per litre (which results in a 54-cent-per-gallon added duty) on imported ethanol (Yacobucci, 2008).

However, most countries in the Caribbean and Central America are granted duty-free access to the US market under the Caribbean Basin Initiative (CBI) and the Central America Free Trade Agreement (CAFTA). Ethanol may be imported duty-free without limitations, if produced from at least 50 per cent local feedstock (e.g. ethanol produced from sugarcane grown in the beneficiary countries). Up to 7 per cent of the US ethanol market may be supplied duty-free by CBI ethanol containing no local feedstock. In this case, hydrous ("wet") ethanol produced in other countries, such as Brazil, can be shipped to a dehydration plant in a CBI country for reprocessing. The Central America Free Trade Agreement sets specific duty-free allocations for imports from Costa Rica and El Salvador. The four largest foreign suppliers of fuel ethanol in the period July 2008-May 2009 were (in descending order): El Salvador, Jamaica, Trinidad and Tobago and Costa Rica. Dehydration plants were operating in all these countries.

Biodiesel

At the 6-digit HS level, bio-diesel is contained in code 382490 which also includes a very large range of unrelated chemical products and preparations. Table 20 shows the top 20 exporters of products classified under this code. For many of these countries, biodiesel represents only a small part of trade, which makes it difficult to analyze the ranking of countries shown. However, The United

States and the EU use more disaggregated tariff schedules which include specific tariff lines for biodiesel. A detailed analysis of these tariff lines is presented as a case study in Annex 2. Given the large weight of HS 382490, which includes biodiesel but also many chemical preparations that are not based on bio-mass, these figures should be interpreted with great care (see also the discussion below in Annex 2).

Table 20: Exports of Chemical Products and Preparations (HS 382490, Includes Biodiesel), 2007

(Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
World	28355.4	All developing countries*	3841.2
Germany	5356.2	China	1032.9
Japan	3125.9	Korea, Rep.	679.7
United States	2933.1	Taiwan, China	550.9
Netherlands	2603.4	Malaysia	457.9
Ireland	2546.5	Singapore	249.0
France	1551.2	Thailand	173.6
Belgium	1426.8	Argentina	155.7
Italy	1090.6	Mexico	105.1
United Kingdom	1076.7	Brazil	68.1
China	1032.9	India	55.3
Korea, Rep.	679.7	South Africa	55.0
Taiwan, China	550.9	Turkey	44.9
Spain	513.7	Hong Kong, China	41.3
Malaysia	457.9	Saudi Arabia	39.0
Switzerland	417.5	Kazakhstan	22.6
Austria	318.7	Viet Nam	20.4
Canada	278.7	Colombia	17.2
Sweden	265.4	Syrian Arab Republic	16.9
Singapore	249.0	Ecuador	13.0
Denmark	232.5	Chile	11.3
EU-total	17457.3		
EU-total (excl intra-EU trade)	5556.1		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

As already mentioned, exports of some countries that appear among the top 20 exporters, such as Ireland, Japan and Switzerland are unlikely to represent biodiesel. However, exports from developing countries such as Argentina, Indonesia, and Malaysia probably consist largely of biodiesel.

With regard to imports, specific data presented in Annex 2 suggest that biodiesel imports into the United States and the European Union represent a growing share of all imports under HS 382490 (representing around 50 per cent, in value terms, in each market). However, it is likely that biodiesel has continued to account for only a very small part of imports into developing countries. This suggests a reduction of imports tariffs in developing countries, if implemented at the 6-digit level, is more likely to boost imports of other chemical products and preparations rather than biodiesel.

Table 21: Imports of Chemical Products and Preparations (HS 382490, Includes Biodiesel)

	2006	2007	2008		2007
All countries	24361.3	28578.0	n/a	All developing countries	11340.2
China	2838.7	2840.2	3068.4	China	2840.2
Germany	2324.2	2495.8	3154.7	Korea, Rep.	1880.1
Korea, Rep.	1571.2	1880.1	n/a	Taiwan, China	1807.7
Taiwan, China	1828.7	1807.7	1658.1	Mexico	681.6
United States	1202.3	1576.8	2936.2	Thailand	562.5
France	965.8	1551.5	1691.5	Hong Kong, China	466.4
Netherlands	996.9	1452.2	2246.0	Turkey	392.9
Italy	1106.4	1159.1	1362.5	Brazil	276.7
Belgium	931.9	1134.7	1646.1	Malaysia	241.7
United Kingdom	1056.4	1133.6	1676.7	Singapore	232.6
Japan	785.5	895.8	1060.0	India	210.5
Spain	616.7	826.6	n/a	Argentina	172.7
Mexico	639.0	681.6	736.5	United Arab Emirates	155.9
Thailand	547.1	562.5	539.3	South Africa	134.0
Canada	483.5	499.3	495.0	Saudi Arabia	128.7
Switzerland	399.0	485.0	530.3	Colombia	123.4
Hong Kong, China	422.0	466.4	497.5	Chile	112.4
Austria	418.7	403.6	485.4	Pakistan	95.6
Turkey	326.2	392.9	489.7	Viet Nam	75.1
Russian Federation	277.1	381.2	440.4	Morocco	71.8
EU-27	10434.7	12638.2	n/a		
Intra-EU trade	8954.4	10240.4	n/a		
EU-27 (excl intra-EU))	1480.3	2397.8	n/a		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Tariffs

Again ad valorem tariffs for biomass equipment and components, in most cases are in the single digits, with a few countries exceeding 10 percent. On the other hand, if we look at trade in undenatured ethanol, tariffs and non-tariff barriers may play a more important role in determining trade in these products. For example, specific tariffs in bio ethanol in some cases are as high as 40 percent on an ad valorem basis (Earley, 2009). It is well documented that subsidies and taxes are distorting trade in this sector. In some countries, however, (e.g. Canada), producer subsidies may be a more important barrier to trade than tariffs (Earley, 2009). Removal of tariffs and non-tariff barriers would be of material importance in generating trade in these markets.

With regard to biodiesel, Annex A4.1 shows that most World Trade Organization (WTO) members use a very large range of tariff lines for HS code 382490. For example, Mexico has 76 tariff lines (the EU has 20 and the United States has 29). The table nevertheless shows that tariffs are relatively low. Taking the average applied MFN tariff for the different tariff lines used in each country, it is estimated that the overall average tariff for HS 382490 applied by major importers is less than 4 per cent ad valorem. The overall average for biodiesel would be only 1 per cent, if each country were to use the lowest tariff for HS 382490 in its own schedule, and around 6 per cent if each country were to use its maximum tariff. Bound rates for products and preparations imported under the provisions of HS 382490 are around 10 per cent on average.

In the United States the general rate of duty for imports of biodiesel (HTSUS code 3824.90.4020) is 4.6 percent ad valorem. In the EU, the third country rate of duty for biodiesel (CN 38249091) is 6.5 per cent ad valorem.

Other sources of Renewable Energy

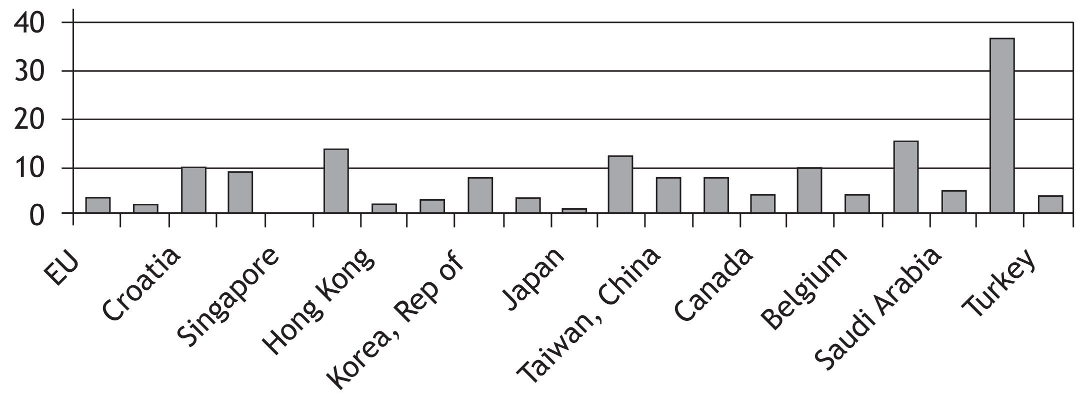
Hydroelectric equipment

Countries with the largest hydroelectric capacity also feature among the top exporters of equipment used in hydroelectric power generation (Annex 3, Table A3.1), with the notable exception of Brazil and Canada which only appear as the 14th and 17th largest exporters of hydro-electric equipment in 2007.

While Brazil and Canada are not leading exporters of hydro-electric equipment, the resource base of Canada is very large, lending itself to the generation of hydroelectricity.

While all the top producers, including Canada, generate products that feature in the list of products imported for the generation of hydroelectricity, imports do not appear to be high. This suggests that the tradable component of this method of electricity generation may represent a small proportion of the total cost of any given project, which usually involves a large amount of engineering work and concrete. Also, given the low volume of trade in the products compared with the value of these contracts, tariffs are unlikely to be an important feature in determining trade in these products. Indeed, all tariffs are below 10 percent, except for a few countries which have 12 to 14 percent tariffs. The latter countries are, nevertheless, important producers of hydroelectricity.

Figure 7: Applied Tariffs on Imports of Hydroelectricity Generation Equipment for 2007



Source: WTO databases using WITS.

Geothermal energy goods

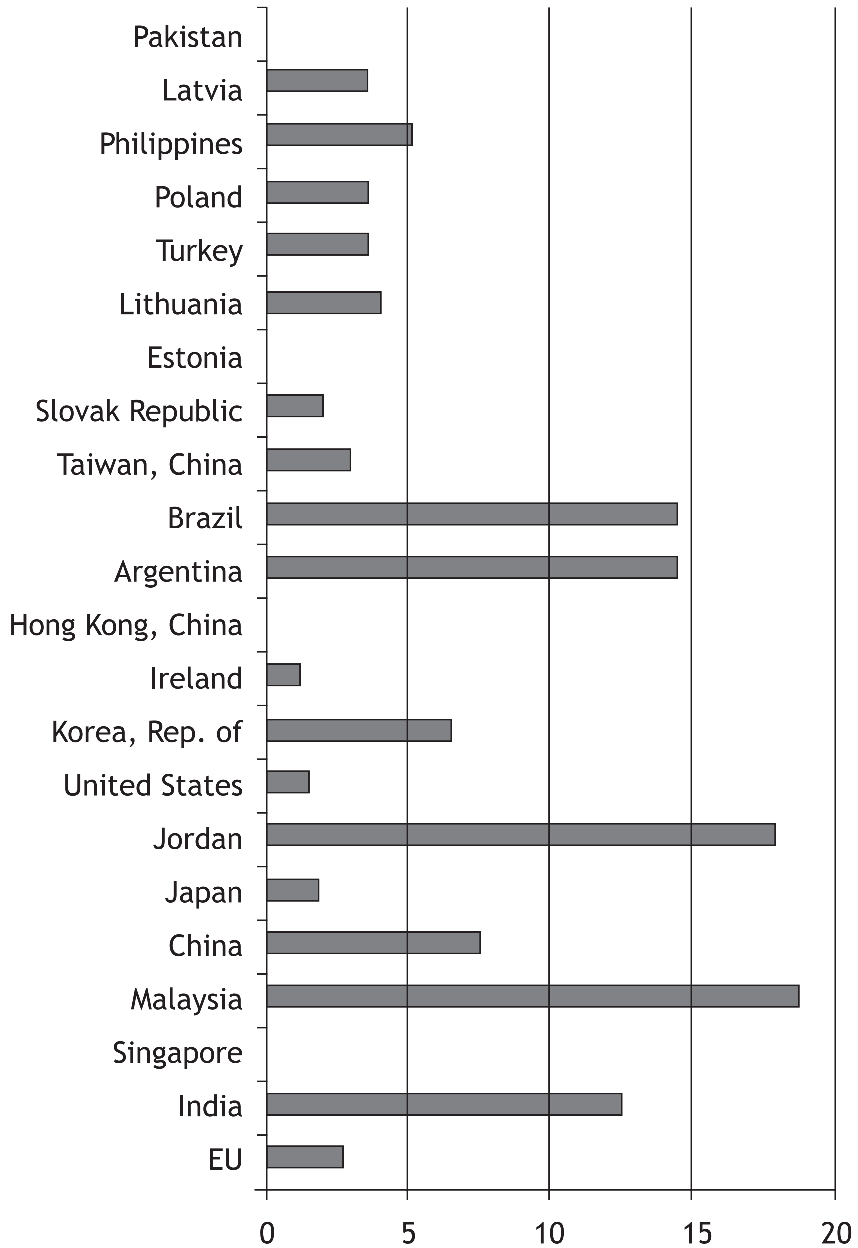
Most of the major producers of geothermal energy also appear on the list of leading exporters of this technology. However, several countries which have larger shares of geothermal energy in their electricity grid, including Costa Rica, El Salvador and Lithuania, do not figure among the top exporters or importers. This shows the limitations of this mapping exercise in linking trade in products with technology deployment. Lund cites the worldwide assessment of the International Geothermal Association (IGA) which ranks the Philippines second to the United States as the world's largest geothermal energy producer; Turkey currently has the fifth highest direct utilization and capacity of geothermal energy in the world (Lund, 2007). Other important countries considered high in potential for development are China, Hungary, Iceland, Mexico and New Zealand. A number of potential sites are being developed or evaluated in South Australia that are several kilometres in depth (Lund, 2004). Many of these geothermal producing countries such as Hungary, Iceland, and New Zealand do not figure among the major exporters of components listed under geothermal energy (Annex 3).

The role of feed-in tariffs and the legal regime is illustrated by the increase in electricity from geothermal sources in Germany. Less than 4 percent of Germany's total primary energy supply came from geothermal sources in 2004. But after a renewable energy law introduced a tariff scheme of €0.15 [US$0.23] per kilowatt-hour (kWh) for electricity produced from geothermal sources came into effect that year, a construction boom was sparked and the new power plants started to come online Germany has also been able to build a new technology that may be more sustainable as geothermal electricity can be generated at lower temperatures now. This would be a great advantage as geothermal energy sources have to be developed sustainably because they can cool off if overused (Geothermal Discussion Forum, 2009).

Geothermal energy deployment depends on the availability of the natural resource. Tariffs have little role to play in the deployment of geothermal energy, except as a potential barrier to import of equipment and components used in geothermal energy generation. At the same time, government policy and investment decisions by commercial banks as well as renewable energy targets may encourage the deployment of geothermal energy. However, the most significant factor guiding the deployment of geothermal energy is the quality of the local resource, although technological improvements in Germany have shown that low-temperature development of geothermal energy is also possible (Geothermal Discussion Forum, 2009).

Liberalization of tariffs of components may stimulate the market, but is unlikely to have a decisive impact. There also appears to be a difference between trade in components along the supply chain and the deployment of geothermal power. This suggests that shafts needed for boring wells may need some adaptation on site.

Figure 8: Applied Tariffs on Geothermal Energy Products for 2007

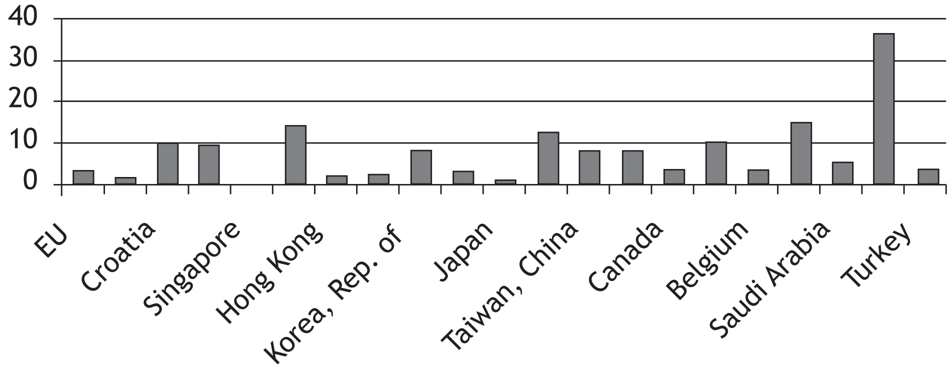


Source: WTO databases, using WITS.

Ocean energy goods, including tidal and wave energy products

There appears to be at best a weak correlation between technologies for ocean energy and countries which are exporters of these technologies. In descending order, the UK, Ireland, Denmark, Norway, US and Canada are the largest generators of ocean energy. However, they do not figure among the top exporters of products linked with ocean energy (Annex 3). This indicates that: (i) the mapping may not be very accurate; and (ii) there may be several dual-use products in the list making for an approximate correspondence between the energy prime movers and the goods in the supply chain. Neither do the top users of ocean energy figure among the top importers of related goods. Thus, the correspondence between the energy and the products is at best very weak. The trade tables also indicate that the traded components of these technologies may not be the most important items in the deployment of these technologies. Goods used in the construction of ocean-energy plants and in connecting the plants to the grid may be more important.

Figure 9: Average Tariffs Applied to Ocean Energy Products for 2007



Source: WTO databases using WITS.

Tariffs do not appear to have a major influence on trade in geothermal energy products or to be an important market driver, as most countries that are major traders apply single digit tariffs. The main market driver is proximity to strong ocean currents and an environment conducive to significant capital investment. The maintenance cost of this renewable energy source also appears to be high. It is also possible that the parts of the supply chain used in this technology are not easily transported. Tradable components may account for a very small proportion of the total technology or the total installation.

Conclusions

Summary

The leading traders of components used in climate-friendly technologies may not necessarily be those that are deploying those technologies. The Doha mandate advocates trade liberalization as a means to deploy these technologies. However, while trade liberalization is important, it may not always spur deployment of climate-friendly technologies, as developing a market for their deployment may depend on the enabling environment. Trade in components plays a relatively minor role in the deployment of a number of technologies such as geothermal energy, ocean energy and hydroelectric power. However, trade in components of wind and solar power may play a relatively more important role as is demonstrated by the increased imports of countries like Germany and Spain, concomitant to their increase in solar and wind energy generation. The provision of subsidies in the form of feed-in tariffs for renewable electricity generation is an important market driver as is the availability of finance and investment. Once markets have been developed through an enabling environment, tariff reduction may make trade easier, but it is unlikely to generate new markets on its own.

4. TRADE AND MARKET DRIVERS

From the above discussion it is clear that production of renewable energy, notably for electrcity generation, is to a large extent driven by feed-in tariffs. However, other market drivers that guide production or deployment of renewable energy technologies may also drive trade. Several large producers of renewables argue that costs would come down if these technologies were exploited in large economies such as India or China. Targets for renewables and an enabling environment for meeting these targets could be two explanatory variables influencing trade. Contrary to the practice in developed countries, most developing countries are unable to offer subsidies in the form of feed-in tariffs. Without such measures, most large companies are unwilling to make investments in developing countries. In fact, at a time when the availability of venture capital is declining due to the financial crisis, especially in developing countries, it is difficult to see how investments in renewables can come about without financial commitments from global funds.

Unequal Government Subsidies and Taxes

The level of subsidies provided by developing and developed countries at all stages of production varies greatly. From the above analysis it is obvious that support provided in the form of large feed-in tariffs, subsidies at the research and development stage, and the availability of large volumes of venture capital led to an explosion in investments in renewable energy during the last decade. However, the trigger variable in most cases was the subsidies provided by the developed countries, both to the producers and the consumers of renewable energy. This has obviously tilted the playing field in favour of developed countries; in the case of tariff reduction on renewable energy supply goods, this would give them a double advantage. This is because their competitiveness has been developed through subsidies, and developing countries which use tariff walls instead of subsidies for the development of their industries would lose such protection. Thus, a level playing field in renewables would demand the simultaneous dismantling of subsidies by the developed countries and tariffs by developing countries.

Global investment in renewable energy worldwide dropped by 53 per cent in the first quarter of 2009 compared with the same period in 2008. The main reasons for this are a fall in conventional energy prices and a slowing in the growth in demand for renewable energy. This was driven in part by the reduction in feed in tariffs, particularly in Spain. The lack of markets in the solar industry, and over-capacity brought down the price of components and reduced the profit margins of solar companies.

This reduction in price in the PV industry and reduction of feed-in tariffs led to the closure of several German component manufacturers. This trend was also observed in other European countries. Europe was once the manufacturing hub of renewable energy components as its governments spent billions in subsidies to encourage utilities and households to install renewable energy technologies (Harvey, 2009).

The United States and China have begun to overtake Europe in both the generation of renewable energy and the manufacture of components. In 2008, the US overtook Germany to become the leading producer of wind energy. China was the second-largest in terms of new wind capacity added in 2008. China also overtook Japan as the biggest manufacturer of photovoltaic components, silicon cells that convert sunlight to electricity and are the building blocks of solar panels (Harvey, 2009).

In the context of ARRA 2009, that was referred to earlier in the context of wind-energy, subsidies to renewable energy components are provided both at the federal level and the state level. The US stimulus package provides US$2 billion worth of energy-related manufacturing investment tax credits at a 30 percent rate. These tax credits apply to projects for manufacturing components of renewable energy. This covers, for example, storage systems for use in electric or hybrid-electric cars, power grid components supporting addition of renewable sources, and equipment for carbon capture and storage) (US Department of Energy, 2009. In addition to federal subsidies, in some states loans would also be provided to component manufacturers of renewable energy generation equipment up to US$35,000 for every new job created[9] (ACORE, 2009). There are media reports, at the time of writing, that China intends to drop the local content requirement for wind projects.

In addition to subsidies of all kinds, production, consumption, grants, loans, write offs, etc, localization may also be one of the important non-tariff barriers in this industry. The world's biggest wind farm, China's Rudong, is unlikely to create any demand for imports for foreign turbine manufacturers such as Vestas, Gamesa and Suzlon. Localization rules require that 70 percent of their equipment to be sourced and built domestically. Foreign firms claim that regulations that prohibit the creation of turbines with capacities of less than 1 megawatt are also a form of restrictive practice that discriminates against them (Bridges Trade BioRes, 2009).

In contrast, developing countries such as India have used tariffs to stimulate their industries. The rates of import tariffs can help to introduce technology and domestic manufacturing, i.e. tax-free for those components not manufactured locally, but high rates for those already made domestically. For example, in India the import tariff for a wind tower is 65 percent, compared to 25 percent for a complete machine. In terms of subsidies, the Indian government allows 100 percent depreciation within the first year for a wind farm, and allows revenues to be tax-free for the first five years (Government of India, 1997).

Due to electricity shortages, power supply is rationed for enterprises in India. This encourages enterprises to invest in captive wind power. Wind electricity can be "banked" at the utility, and if the power supply is cut or reduced, those enterprises have priority to get a power supply. Also, the power from wind farms can be "wheeled" through the utility grid to the enterprises for a modest charge, typically 2 percent of the value. The Indian Renewable Development Agency is able to offer "soft" loans for wind farm developers with interest rates that are lower than those offered by commercial banks (Government of India, 2008).

In summary, the main measures used in developed countries to stimulate renewable energy markets have been:

- Laws requiring utilities to purchase all electricity generated from renewables;
- Laws requiring renewables to be a certain percentage of all power generation;
- Subsidies for investments in component manufacturing;
- Exemptions or reductions in taxes for component manufacturers;
- Preferential tariffs for electricity from renewables.

The main measures used by developing countries have been tariffs and in some cases, e.g. China, localization requirements.

Is Intellectual Property a Barrier to the Dissemination of Renewables?

Apart from tariffs and subsidies, intellectual property can also be a major deterrent to the dissemination of renewable energy technologies. While there are many forms of intellectual property, information on patents for renewables is available (CERNA, 2008). The number of patents registered in the renewable energy sector in different countries would indicate the extent to which renewable technologies are likely to be commercially exploited in the countries in which the patents are registered. However, patents are not the only intellectual property protection that can be granted to a new technology. Technology transfers also involve the transfer of know-how which can be protected by trade secrets or other forms of intellectual property.

The number of patents that have been registered in the renewable sector in different countries could provide an indication of the dissemination of renewables across borders. Presumably, patents are registered in a particular country because the patent holders want to exploit that particular technology commercially in that country. This implies that the number of patents registered would provide a measure of the eventual dissemination of renewable energy technologies. In 1998, 5 percent of the patents for relevant technologies was registered in a developing country; in 2008 it was one in five. However, even more striking than the gap between developed and developing countries is the gap between different groups of developing countries. A small group of emerging market economies accounts for nearly all patents registered (99.4 percent of all protected patents in the sampled countries), and a large group of low-income developing countries accounts for as little as 0.6 percent only of the total sample. Although there was a rapid and very significant increase in resident patent holders in emerging market economies (33 percent growth over the period 1998-08), the increase occurred almost exclusively in China: of the 7,400 locally owned patents, nearly 6,800 are owned by residents in China. In China, 40 percent of the sampled technology patents are locally owned. On the other hand, in India, less than 14 percent of the registered patents are locally owned (CERNA, 2009).

Globally, some 215.000 patent applications were filed in the renewable energy sector over the period 1998-2008, with about 22.000 in developing countries. Of this only about 7,400 were actually owned by developing country residents. When the last four years of the period are compared to the first four years, the global patent count doubled, but increased by five times in developing countries. Solar energy and fuel cell patents accounted for 80 percent of this increase, followed by wind energy as a distant second (Copenhagen Economics A/S and IPR company Aps, 2009).

Transfer of climate mitigation inventions is less likely than other technologies. Transfers of such technologies mostly take place between developed countries (75 per-cent of exported inventions). North-South transfers are still limited (18 percent) but are growing rapidly. Technology transfers between emerging economies are very low. Finally, the imports of technologies may crowd out local innovations: the higher the number of imported inventions, the lower is the local technological invention in the recipient country (CERNA, 2008).

Regression Analysis

In statistics, a multivariate regression analysis refers to techniques for modelling and analyzing several variables, when the focus is on the relationship between a dependent variable and several independent variables. More specifically, regression analysis shows how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. In all cases, the estimation target is a function of the independent variables called the regression function. In regression analysis, it is also of interest to characterize the variation of the dependent variable around the regression function, which can be described by a probability distribution.

Looking at the above analysis, it is likely that the higher the feed-in tariffs and other subsidies, the more likely an economy is to export renewable energy components. The sensitivity of exports and imports of renewable equipment to feed-in tariffs may vary across the specific sub sector, e.g. may be higher in wind and solar than in others as was shown above. Furthermore, tariffs on components may affect the import of renewable energy components; the higher the tariffs, the lower the imports, and vice versa. The tariff sensitivity of imports may be limited in some sectors such as solar and wind, while other factors could be more important. Another variable that could be important is the number of patents registered. The higher the number of patents, the larger the volume of exports of renewable energy components is likely to be, as patents may be strongly linked with foreign direct investment (FDI) and exports. Similarly, the greater the contribution of renewables in the energy grid, the export of components is likely to be larger, as these countries are likely to benefit from specialization in specific renewables.

To examine the main drivers of exports of components of renewable energy, based on the evidence presented above, four explanatory variables were selected for a regression analysis. A multivariate cross country regression analysis was conducted to identify the important drivers. The explanatory policy variables which were examined were tariffs on imports, the percentage of renewables in the electricity grid, and the percentage of inventions as shown by the share of the country in global patents. Another explanatory variable is the subsidies provided to renewables. All subsidies specified above have been included. A dummy variable which shows the presence or absence of subsidies has been used in this regression analysis. The data used in this regression analysis is shown in Table 22.

Table 22: Regression Data

Country	Tariffs	Subsidies Renewables	% Electricity from Renewables	% Inventions
European Union	3.00%	1	14	17
Germany	3.00%	1	11.5	12.7
China	8.00%	1	17	5.8
United States	1.00%	0.5	9.2	12.8
Japan	0.50%	0.5	10	40.8
France	3.00%	1	11	2.4
Italy	3.00%	1	16	0
South Africa	1%	0	0	0.03
Korea, Rep.	8%	0	0.4	4.6
United Kingdom	3.00%	0	4	1.9
Mexico	11.50%	0	16	0.1
Canada	2%	0.5	59	1.5
Belgium	3%	1	2.8	0
Netherlands	3%	1	8.2	0
Taiwan, China	4%	0	0	0.7
Singapore	0%	0	0	0
Spain	3%	1	19	0
Czech Republic	3%	1	4.2	0
Sweden	3%	0	49	0
Austria	3%	1	62	0
Malaysia	2%	0	0	0
Saudi Arabia	0%	0	0	0
Thailand	2%	1	7	0
India	25%	0.5	4	0.2
Brazil	10%	1	75	1.3
Argentina	9%	1	35	0

Table 22. ***Continued***

Country	Tariffs	Subsidies Renewables	% Electricity from Renewables	% Inventions
Tunisia	0%	0	0	0
Philippines	2%	0	0	0
Colombia	16%	0	0	0
Jordan	0%	0	0	0
Kazakhstan	0%	0	0	0
Turkey	2%	1	0	0
Georgia	0%	0	0	0
Oman	2%	0	0	0

Source: (1) Data for exports and imports and tariffs were obtained from WITS; (2) Data for subsidies includes feed-in tariffs and subsidies to component manufacturers. Data on % of renewables refers to the actual percentage of renewable energy in the grid. The data were obtained from the International Energy Agency, World Energy Outlook 2007; (3) Data for % of inventions were derived from the CERNA study referred to above.

The table shows that the major exporting countries of renewable technologies, equipment and components are also likely to patent inventions, use a high percentage of renewables showing high deployment of renewable energy, provide subsidies and have low tariffs (Table 1 and Table 15). However, some outliers are clearly visible. One of the most important exceptions to this general rule is Japan. Japan has a high share of patents, about 41 percent, but ranks lower in terms of exports (Table 1). This could in part be explained by the fact that Japanese multinationals may be registering defensive patents in Japan and exploiting these commercially in other countries, notably China. The share of renewable energy in the total energy supply of countries like Austria, Brazil, Canada and Sweden are very high even though they do not emerge as major traders of renewable energy technologies. This is accounted for by the high share of hydroelectricity in their grids; in the case of Brazil and Sweden, it is accounted for by their large consumption of biofuels and biomass. While most developed countries provide subsidies and regulations requiring a high share of renewables in the energy supply, emerging economies also do so either in part or full. Applied tariffs in general are quite low for most countries except for the emerging economies which have double-digit tariffs.

In terms of relationships we expect that the higher the percentage of renewables in the grid, the higher the exports would be. This follows from the logic that when deployment of renewables is high, specialization would result in a higher level of exports. Similarly, government support for component manufacturers would increase exports, as it is likely to result in higher specialization and production. Feed-in tariffs may also stimulate imports as it would encourage investment, both domestic and foreign. The number of patents is an indication of the degree of specialization of a country, both by domestic and foreign investors, and hence is also likely to increase exports. On the basis of this relationship, the following equation was tested:

Exports=f (tariffs, subsidies for component manufacturers, share of renewables in the grid, share of global patents)

The regression results are shown below:

Regression Result
Dependent variable: log (Export) of RES

Dummy variable on invention	1.89*** (0.440)
Log (% renewables)	0.248*** (0.088)
Log (tariffs)	-0.234 (0.155)
Log (feed-in tariffs on renewables)	-0.031 (0.125)
R-sq	0.60
F (4,29)	11.0***
Number of observations	34

**** Significant at 1%*

The results show that inventions and the proportion of renewables affect exports of renewables positively. However, import tariffs and subsidies to the renewable sector as a whole affect exports negatively. The correlation is, however, found to be insignificant, i.e. the probability of the relationship being robust is extremely low. In the case of the first two variables, the correlation is extremely significant, i.e. the chance that the relationship is not robust is only 1 percent. One explanation of the insignificant relationship between subsidies and exports could be because the percentage of renewable in the grid is likely to be affected by the level of supportive subsidies such as feed-in tariffs or subsidies to component manufacturers. This is a situation of multicollinearity[10] of the explanatory variables. In order to account for it, statistically a composite variable was constituted using their Eigen values. In this case, the relationship between the composite variable, comprising the percentage of renewable in the grid and subsidies, and exports of renewable energy goods was found to be significant at the 1 percent level. This implies that only in 1 percent of the cases, would the relationship not be robust. The composite variable had a positive correlation with exports, implying that the higher the subsidies and the higher the share of renewables in an economy, the higher the economy's exports. Tariffs were shown to have an insignificant correlation to exports.

Regression Result on RES:
Correlation Between Variables

Log (% from renewables)	1.00		
Log (tariffs)	0.557	1.00	
Log (subsidies)	0.705	0.392	1.00

Principle Component Analysis

	Eigen value	Proportion
Component1	1.70	85.2%
Component2	0.294	14.8%

Eigen Vector

	Component 1
Log (% renewables)	0.707
Log (feed-in tariffs)	0.707

Regression
Dependent Variable Log (Export of RES)

Log (inventions)	0.259*** (0.056)
Log (tariffs)	-0.094 (0.152)
Composite index	0.410** (0.191)
R-sq	0.56
F (3,30)	12.99***
Number of observations	34

Similar correlations were observed with the policy explanatory variables for solar and wind energy. These relationships show that exports can be incentivized through an effective policy on increasing the share of renewables and the provision of subsidies. Reduction of tariffs may not affect exports of renewables.

Dependent Variable Log (Export of Components of Solar–Energy)

Log (inventions)	0.415*** (0.140)
Log (tariffs)	0.387 (0.383)
Composite index	0.946** (0.481)
R-sq	0.48
F (3,30)	9.59***
Number of observations	34

Dependent Variable Log (Export of Components of Wind–Energy)

Log (inventions)	0.234 (0.154)
Log (tariffs)	0.359 (0.420)
Composite index	0.976** (0.527)
R-sq	0.33
F (3,30)	5.03***
Number of observations	34

Turning to imports, it is generally assumed that tariff reduction would lead to an increase in imports. But even in this case, policy variables such as the share of global patents and share of renewables as well as subsidies affect imports of renewables as well as components of wind and solar energy. All these relationships are significant at the 5 percent level. This analysis points to the fact that tariff reduction by itself may not generate trade in renewables. Other support policies, targets and standards, shown by the share of renewable in the energy grid, may be more important in determining trade flows. The deployment of renewable energy, which should be the end result of opening trade, would need several enabling policies and notably subsidies or regulation to generate gains for climate change.

Dependent Variable Log (Import of Solar–Energy)

Log (inventions)	0.486*** (0.144)
Log (tariffs)	0.253 (0.392)
Composite index	0.810 (0.492)
R-sq	0.475
F (3,30)	9.05***
Number of observations	34

Dependent Variable Log (Import of Wind–Energy)

Log (inventions)	0.411*** (0.136)
Log (tariffs)	0.019 (0.369)
Composite index	1.00** (0.464)
R-sq	0.45
F (3,30)	8.36***
Number of observations	34

*NB: Standard err are in parenthesis; *** significant at 1%; ** significant at 5%; * significant at 10%.*

Another policy variable that needs discussion is the issue of patents in generating trade in renewables. Studies such as those done by CERNA and the Copenhagen Business School suggest that patents may not be a barrier to the dissemination of renewable technologies. This may be true, but it is also clear from the above analysis that firms which want to exploit these technologies and export their components may also first patent their technologies in the country of exploitation. Over two thirds of the patents in developing countries are owned by non-residents. This also implies that multinationals may be registering these patents defensively, establishing a production base and exporting components of these technologies from developing countries. The fact that they feel the need to register these patents suggests that the technologies may be copied or that they may be embedded in the parts that they are exporting. Thus, patents and the associated specialization have an important role to play in the exports of the components of renewables.

Undenatured ethanol which accounts for most of the trade as well as usage of biofuels shows a different set of drivers. In this case, only the composite variable (comprising the share of renewables in the grid and subsidies given to achieve that target) is shown to affect trade, and not patents.

Regression on Ethanol:

Dependent Variable Log (Export of un–Denatured–Ethanol)

Log (inventions)	0.008 (0.118)
Log (tariffs)	-0.407 (0.375)
Composite index	1.71*** (0.414)
R-sq	0.43
F (3,23)	5.99***
Number of observations	34

Summing Up

To sum up, tariff reduction by itself is unlikely to generate trade in components and technologies of renewable energy. From a trade point of view, subsidies would distort the level playing field and go against free and perhaps fair trade. On the other hand, from an environmental point of view, subsidies have played a crucial role in generating markets for renewable energy and hence for climate change mitigation efforts. However, as an industry becomes competitive and costs come down, subsidies can also be phased out. Patents are by no means unimportant in determining trade in renewables; however, whether patents are preventing the dissemination of renewable technologies is another issue and has not been explored in this paper. Inadequate patent protection may prevent investment and trade in renewables. Patents are also an indicator of specialization and indicate the trading capacity of a nation for renewable energy components and technologies.

5. CONCLUSIONS

The analysis above shows that there is often a distinction between the tradable components of a renewable technology and the establishment of the renewable energy plant. In several cases, countries which have established a capacity to deploy renewables are not those which are trading in parts, with the exception of China. In fact, initially, as in the case of solar energy, all components are produced by the country that generates the renewable energy. However, as technology develops, other countries join in production, bringing down costs and increasing the divisibility of the supply chain. Thus, there is a logical case to be made for liberalizing trade in these components as they are likely to generate win-win solutions. As is evidenced by the increase in developing countries with renewable energy targets, demand for these technologies – knowledge and products – will likely continue to rise.

Liberalizing tariffs, however, may not guarantee a diffusion of these technologies or the creation of markets for products used in these technologies in developing countries. Markets in developed countries have grown exponentially during the last few years in response to the subsidies provided for renewable energy consumption, tax breaks, subsidies for components and the huge volume of venture capital investment (EER, 2007). Given the grip of the economic and the financial crisis it is unlikely that such venture capital will come to developing countries. It is also likely that subsidies or incentives to the green economy in developed countries will increase through the stimulus packages. This would be a double whammy for developing countries that have the capacity to develop renewables on their own. On the one hand, they would have to reduce their tariffs (which are only high in a few emerging economies that have the capacity to produce these products), and on the other, they would be exposed to competition from subsidized products from developed countries. In addition to products and components subsidies, research and development and consumption subsidies would have a large impact on the demand structure and markets for these industries. In a way, the discussion in the context of the WTO should be similar to that of agriculture, i.e. parity should be established between the two pillars of the RES industry: the overall level of support for the RES industry and the tariffs in the RES industry.

In terms of trade negotiations, it should be borne in mind that only a handful of developing countries are important players in the markets or trade in renewables. This market is essentially dominated by developed countries. This implies that trade negotiations could involve approaches like request and offer for quick and effective results, based on the top 20 exporters and importers. This is particularly true when an environmental end-use may not be as significant at the HS 6-digit level as in the case of predominantly single end-use products.

Another factor that needs to be considered is that the 6-digit mapping exercise is at best an approximation. This implies that trade at the 6-digit level would result in trade in several multiple-use products as was shown above by the frequent discordance between deployment of renewable energy technologies and trade in components. However, if negotiations are confined to those single-use items shown in the paper, environmental gains may be more certain. In this situation, tariff reduction in single- use items may meet the objectives of the Doha Round. In addition, the possibility of reducing bound tariffs on a specific list of products by most, if not all, members of the WTO may be much less controversial. For the larger lists shown here, gradual and sequenced liberalization may be an important part of an emerging economy's industrial strategy.

Further barriers to the dissemination of these technologies need to be identified and addressed. While patents may not pose an insurmountable barrier to the dissemination of renewable energy technologies, other forms of intellectual property (IP) protection, such as trade secrets, may be important. Indeed, patents have been seen to correlate positively with trade in renewable energy components. Many other non-technological and more economic factors stand in the way of achieving the carbon abatement objectives of developing countries, such as insufficient technical knowledge and absorption capacity to produce these innovative technologies locally, insufficient market size to justify local production units, and insufficient purchasing power and financial resources to acquire the innovative products. Each of these factors deserves considerable discussion. Solutions, if needed, should be sought in policies that aim to overcome these insufficiencies. Even without access to technology, some domestic policies could have a high direct pay-off for domestic industry, For instance, domestic targets on renewables could stimulate domestic industry and trade. Financial support should compensate developing countries for the overall economic burden of carbon abatement while preserving the countries' incentive to minimize the costs of that abatement. This is particularly important in the context of a global public good such as mitigating climate change. If developed countries provide subsidies to stimulate the development of their renewable energy industry, some financial compensation should also be provided to developing countries to invest in their renewable energy industries in the interest of a global good, i.e. mitigating climate change. Issues pertaining to localization of components used in the generation of renewable energy also need to be explored.

ENDNOTES

1 Trade openness refers to the removal of barriers to trade. Barriers to trade include tariffs and non-tariff barriers such as subsidies, stringent standards, anti-dumping, and safeguard action.

2 For details, see Annex 1.

3 This product is also examined in a forthcoming paper for ICTSD on the buildings sector.

4 Sources of information and software systems used to generate trade and tariff statistics presented in this paper:
Sources of information on trade:
At the 6-digit HS level for all reporters:
The United Nations Commodity Trade Statistics Database (COMTRADE), http://comtrade.un.org/db), using the World Integrated Trade Solution (WITS), a software system developed by the World Bank (in cooperation with UNCTAD) which can be accessed on-line (http://wits.worldbank.org/witsweb/). COMTRADE compiles trade statistics reported by over 200 countries and territories.
At the more detailed level of the European Union (8-digits) and the United States (10 digits).
The Harmonized Tariff Schedule of the United States (HTSUS), using the USITC Interactive Tariff and Trade DataWeb (http://dataweb.usitc.gov/). Data have been compiled from tariff and trade data from the U.S. Department of Commerce and the U.S. International Trade Commission. Import statistics shown in this paper refer to U.S. Imports for Consumption (customs value) whereas export statistics refer to U.S. Domestic exports (FAS (free alongside ship) value).
The EU Common Nomenclature (CN), using the Export Helpdesk for Developing Countries (http://exporthelp.europa.eu/index_en.html), an online service provided by the European Commission.
Sources of information on tariffs:
Tariff data are extracted from WTO databases, using WITS and the WTO Tariff Download Facility (http://tariffdata.wto.org/) to access information on applied rates contained in the Integrated Data Base (IDB) and WTO bound rates contained in the Consolidated Tariff Schedule Data Base.

5 Ireland appears as one of the key exporters in Table 3, but not in Table 1. This can be explained by the relatively high weight of trade under HS 382490 (mostly unrelated to biodiesel) in Ireland's exports).

6 The tariff that is currently applied to a product is known as the "applied tariff." A country can presently choose to have the tariff on a product "bound" at a certain level. In this case, the country commits that the tariff cannot exceed that level in future, and this bound level can be higher than the applied rate, so that there is still some leeway to raise the applied tariff if there is a need to do so.

7 In the case of solar water heaters, tariffs in the largest import markets are also very low. The United States and Canada (the first and third import market respectively for products under HS 841919) have bound their tariffs at zero rates. In the European Communities, applied and bound tariffs are 2.6 percent ad valorem. However, the Russian Federation and some developing countries provide tariff protection for products under HS 841919.

8 Much of the growth in US demand for fuel ethanol has resulted from the Clean Air Act (which requires that gasoline in areas with the worst ozone pollution contain an oxygenate, such as

ethanol) and the establishment of the RFS in the Energy Policy Act of 2005 (which requires that gasoline sold in the United States contain a renewable fuel, such as ethanol). The Energy Independence and Security Act of 2007 expanded the RFS requirements to 9 billion gallons in 2008, increasing to 36 billion gallons in 2022 and specifically required the use of an increasing amount of “advanced bio-fuels”, i.e. bio-fuels produced from feedstock other than corn starch, including sugar cane ethanol (Yacobucci, 2008).

9 Loans for geothermal systems or wind energy generation or distribution projects shall not exceed US$5 million. Grants will be awarded to component manufacturers of renewable energy generation equipment up to US$5,000 for every new job created. Grants for geothermal systems or wind energy generation or distribution projects are available up to US$1million per project. Grants for planning and feasibility studies will cover up to 50 percent of the total cost of planning the project or US$175,000, whichever is less (ARRA, 2009).

10 Multicollinearity is a statistical phenomenon in which the explanatory variables, i.e. feed-in tariffs and percentage of renewable energy in the grid, are highly correlated. Multicollinearity does not reduce the predictive power or reliability of the model as a whole; it only affects calculations regarding individual explanatory variables.

ANNEX 1: HS CODES FOR RENEWABLE ENERGY TECHNOLOGIES AND COMPONENTS

Table A1.1: 6-Digit HS Codes and Renewable Energy Technologies

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
220710	Undenatured ethyl alcohol	3213.9	Added	Bio-ethanol	It is not possible to know from trade statistics at the 6-digit HS level how much is used for fuel. From July 2008, the HTSUS includes a new 10-digit code (2207106010) for US imports of undenatured ethyl alcohol for fuel use. US Imports under the provisions of this item accounted for more than 90 percent (in value terms) of total US imports under the provisions of HS 220710 in the period July 2008-May 2009
220720	Ethyl alcohol and other spirits	935.3	Added	Bio-ethanol	It is not possible to know from trade statistics at the 6-digit HS level how much is used for fuel. From July 2008, the HTSUS includes a new 10-digit code (2207200010) for US imports of denatured ethanol for fuel use. US Imports under the provisions of this item accounted for more than 80 percent (in value terms) of total US imports under the provisions of HS 220720 in the period July 2008-May 2009
380210	Activated carbon	815.0		Biomass (Activated carbon that includes carbon molecular sieve used for process of purification of bio-ethanol).	
382450	Non-refractory mortars and concretes	780.4		Hydro	
382490	Other chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included: other	28355.4	Biodiesel (This category could include chemicals used in purification of biofuel as well as bio-diesel itself).		It is not possible to know from trade statistics at the 6-digit HS level how much trade is used for fuel. In the United States, the 10-digit HTSUS code for biodiesel is 3824904020. US biodiesel imports have increased in recent years and in 2008 accounted for almost half of the value of all US imports under the provisions of HS 382490. In the EU a separate code for biodiesel (CN 38249091) was introduced in January 2008. This code covers fatty-acid mono-alkyl esters (FAMAE), although other forms of biodiesel could still enter the EU under other codes depending on the chemical composition. EU-27 imports under the provisions of this CN code accounted for 28 percent of total EU-27 imports (43 percent if intra-EU trade is excluded) under the provisions of HS 382490 in 2008.

Table A1.1. *Continued*

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
392690	Other	34759.5	Excluded		
681091	Prefabricated structural components	1574.4		Hydro	
700991	Glass mirrors, unframed	764.8		Solar	
700992	Glass mirrors, framed	710.4		Solar	
711590	Other articles of precious metal or of metal clad with precious metals, other	2295.2		Solar	
730431	Pipes and tubes	1995.2	Excluded	Solar, geothermal	
730441	Pipes and tubes	2641.7	Excluded	Solar, geothermal	
730451	Pipes and tubes	661.6	Excluded	Solar, geothermal	
730820	Towers and lattice masts	1872.4		Wind	
730890	Other structures	25332.3	Excluded	Solar	
730900	Reservoirs, tanks, vats and similar	3816.5	Excluded	Biomass	
732290	Radiators for central heating, air-heaters, hot air-distributors non-electric, other	1127.7	Added	Solar air heaters	
741121	Tubes and pipes, of copper-zinc base alloys (brass)	804.6	Excluded	Biomass, geothermal	
741122	Tubes and pipes, of copper-nickel or copper-nickel-zinc base alloys	429.4	Excluded	Biomass, geothermal	
741129	Other tubes and pipes	638.4	Excluded	Biomass, geothermal	
741999	Other articles of copper, other	2891.9	Excluded	Biomass	
761090	Aluminium structures, other	6352.5	Excluded	Solar	
761100	Aluminium reservoirs, tanks, vats and similar containers, of a capacity exceeding 300 litres	168.0	Excluded	Biomass	
830630	Photograph, picture or similar frames, mirrors; and parts thereof	317.9		Solar	

Table A1.1. ***Continued***

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
840681	Steam turbines and other vapour turbines, of an output exceeding 40 MW	509.8		Biomass	
840682	Steam turbines and other vapour turbines, of an output not exceeding 40 W	799.3		Biomass	
841011	Hydraulic turbines of a power not exceeding 1,000 kW	45.0		Used in hydro energy	
841012	Hydraulic turbines of a power exceeding 1,000 kW but n	45.1		Used in hydro energy	
841013	Hydraulic turbines of a power exceeding 10,000 kW	72.9		Used in hydro energy	
841090	Hydraulic turbines: parts, including regulators	865.0	Added	Used in hydro energy	
841280	Other engines and motors	1148.7		Solar	
841290	Other engines and motors: parts	6541.0		Blades for wind turbines	
841181	Other gas turbines, of a power not exceeding 5,000 kW	540.0	Excluded	Biomass	The 10-digit HTSUS distinguishes gas turbines for aircraft and other use. Gas turbines imported into the US under HS 841181 are largely for aircraft.
841182	Other gas turbines, of a power exceeding 5,000 kW	3050.2	Excluded	Biomass	The 10-digit HTSUS distinguishes gas turbines for aircraft and other use. Gas turbines imported into the US under HS 841182 are largely for "other" use, which may include the bio-mass sector.
841620	Other furnace burners, including combination burners	919.7		Biomass	
841861	Heat pumps other than air conditioning machines of heading 8415	4414.7		Geothermal heat pump	

Table A1.1. *Continued*

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
841919	Instantaneous or storage water heaters, nonelectric	1653.4	Added	Solar water heaters Listed in several studies on renewable energy products, although strictly speaking not a renewable energy supply product	The HTSUS distinguishes 3 sub-items: instantaneous water heaters (HTSUS 8419.19.00.20), solar water heaters (HTSUS 8419.19.00.40); and "other" (HTSUS 8419.19.00.60). US imports of solar water heaters accounted for less than 5 percent of water heaters imported under the provisions of 841919, in value terms, on average, in the period 2006-2008. Most imports came from China. Imports under HTSUS 8419.19.00.60 ("other"), mostly from Mexico, were far more important.
841931	Dryers: for agricultural products	331.0		Biomass	
841940	Distilling or rectifying plant	1050.0		Biomass	
841950	Heat exchange units	8414.3		Geothermal	
841989	Other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: other	6515.3		Biomass	
841990	Other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: parts	6515.3		Solar	
842129	Filtering or purifying machinery and apparatus for liquids: other	4742.6	Excluded	Biomass	
842139	Filtering or purifying machinery and apparatus for gases: other	13224.0	Excluded	Biomass	
847920	Machinery for the extraction or preparation of animal or fixed vegetable fats or oils	618.5		Biomass	

Table A1.1. ***Continued***

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
847989	Machines and mechanical appliances having individual functions, not specified or included elsewhere in chapter 84: other	57903.9	Excluded	Biomass	
848210	Ball bearings	10347.4		Wind turbine components	
848220	Tapered roller bearings	3586.4		Wind turbine components	
848230	Spherical roller bearings	2268.7		Wind turbine components	
848240	Needle roller bearings	917.4		Wind turbine components	
848250	Other cylindrical roller bearings	1944.7		Wind turbine components	
848280	Other ball or roller bearings	1398.9		Wind turbine components	
848340	Gears and gearing, other than tooth	12908.2		Wind turbine components	
850161	AC generators (alternators): of an output not exceeding 75 kVA (kilovolt ampere)	817.5		Wind, hydro and biomass	
850162	AC generators (alternators): of an output exceeding 75 kVA but n	571.9		Wind, hydro and biomass	
850163	AC generators (alternators): of an output exceeding 375 kVA but	294.4		Wind, hydro and biomass	
850164	AC generators (alternators): of an output exceeding 750 kVA	2685.0		Wind, hydro and biomass	
850231	Other generating sets: wind-powered	3910.9		Wind turbines	
850239	Other generating sets: other	2692.6		Solar, ocean energy	
850300	Parts suitable for use solely or principally with the machines of heading 8501 or 8502	15952.1	Added	Used for wind turbines	Listed in USITC study.

Table A1.1. ***Continued***

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
850421	Liquid dielectric transformers: having a power handling capacity not exceeding 650 kVA:	1557.4		Hydro, wind and ocean energy	
850422	Liquid dielectric transformers: having a power handling capacity of 650 kVA - 10,000 kVA	1167.6		Hydro, wind and ocean energy	
850423	Liquid dielectric transformers: having a power handling capacity exceeding 10,000 kVA	3585.4		Hydro, wind and ocean energy	
850431	Electric transformers, having a power handling capacity less than 1 kVA	3867.5		Hydro, wind and ocean energy	
850432	Electric transformers, having a power handling capacity of 1 kVA -16 kVA	516.8		Hydro, wind and ocean energy	
850433	Electric transformers, having a power handling capacity of 16 kVA - 500 kVA	852.4		Hydro, wind and ocean energy	
850434	Electric transformers, having a power handling capacity exceeding 500 kVA	1575.3		Hydro, wind and ocean energy	
850440	Static converters	28623.4		Solar	
853710	Bases for electric control or the distribution of electricity, for a voltage not exceeding 1,000 V	24395.0	Excluded	Wind	
853720	Bases for electric control or the distribution of electricity: for a voltage exceeding 1,000 V	3874.8	Excluded	Wind	

Table A1.1. ***Continued***

6-Digit HS Code	Product Description (for 6-Digit HS Code)	World Exports in 2007 (US$million)	Analysis Vis-à-Vis ECN List	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes	25520.3		PV panels	PV modules fall under HS 854140. This 6-digit code also includes unrelated light-emitting diodes. The EU 8-digit CN classification includes separate sub-heading for light-emitting diodes and "other". The latter sub-heading (CN 85414090) represented more than 90 percent of EU imports under HS 854140 in 2008. HS code 854140 would thus seem to be a reliable indicator of trade in PV modules.The HTSUS breaks HS 854140 down into 8 national sub-headings, two of which explicitly cover solar cells. These two items together represented 45 percent of total US imports under the provisions of HS 854140. The 6-digit code would appear to be a reasonable indicator of trade in PV modules.
854449	Other electric conductors, for a voltage not exceeding 80 V	1596.4		Ocean	
854460	Other electric conductors, for a voltage exceeding 1,000 V	6013.7		Ocean	
890790	Other	973.9		Wind	
900190	Other (including lenses and mirrors)	5762.7		Solar	
900290	Other optical elements (including mirrors)	1623.1		Solar	
900580	Other instruments	324.3		Solar	
901380	Other devices, appliances and instruments	46624.3	Excluded	Solar	
902830	Electricity meters	1357.0		Wind	
903020	Cathode-ray oscilloscopes	332.7		Wind	
903031	Multi-meters	472.7		Wind	
903039	Other instruments and apparatus for measuring or checking voltage, current or resistance, with a recording device	1362.3		Wind	
903289	Automatic regulating or controlling instruments, other	15066.1	Excluded	Wind	

Table A1.2: Weights of 6-Digit HS Codes in Total Imports of Renewable Energy Technologies
(Based on 2007 World Import Values)

6-Digit HS Code	Renewable Energy Sectors						
	All	Solar Energy	Wind Energy	Biomass	Hydro Energy	Geo-Thermal Energy	Ocean Energy
220710	1.34			6.56			
220720	0.39			1.91			
380210	0.34			1.66			
382450	0.32				3.74		
382490	11.80			57.87			
681091	0.66				7.54		
700991	0.32	0.82					
700992	0.30	0.76					
711590	0.96	2.45					
730431	0.83					8.79	
730441	1.10					11.64	
730451	0.28					2.92	
730820	0.78		2.13				
732290	0.47	1.21					
741121	0.33					3.55	
741122	0.18					1.89	
741129	0.27					2.81	
830630	0.13	0.34					
840681	0.21			1.04			
840682	0.33			1.63			
841011	0.02				0.22		
841012	0.02				0.23		
841013	0.03				0.35		
841090	0.36				4.14		
841182	2.72			13.35			
841280	0.22	0.58		1.10			
841290	1.27		3.48				
841620	0.38			1.88			
841861	1.84					19.45	
841919	0.69	1.77					
841931	0.14			0.68			
841940	0.44			2.14			
841950	3.50	9.01				37.08	
841989	2.71	6.98					
841990	2.71	6.98					
847920	0.26			1.26			
848210	4.31		11.79				
848220	1.49		4.09				
848230	0.94		2.59				

Table A1.2. ***Continued***

6-Digit HS Code	Renewable Energy Sectors						
	All	Solar Energy	Wind Energy	Biomass	Hydro Energy	Geo-Thermal Energy	Ocean Energy
848240	0.38		1.05				
848250	0.81		2.22				
848280	0.58		1.59				
848340	5.37		14.71				
850161	0.34		0.93	1.67	3.92		
850162	0.24		0.65	1.17	2.74		
850163	0.12		0.34	0.60	1.41		
850164	1.12		3.06	5.48	12.86		
850231	1.63		4.46				
850239	1.12	2.88				11.87	11.49
850300	6.64		18.18				
850421	0.65		1.77		7.46		6.65
850422	0.49		1.33		5.59		4.98
850423	1.49		4.09		17.18		15.31
850431	1.61		4.41		18.53		16.51
850432	0.22		0.59		2.48		2.21
850433	0.35		0.97		4.08		3.64
850434	0.66		1.80		7.55		6.73
850440	11.92	30.64					
854140	10.62	27.32					
854449	0.66		1.82				6.82
854460	2.50		6.85				25.67
890790	0.41		1.11				
900190	2.40	6.17					
900290	0.68	1.74					
900580	0.14	0.35					
902830	0.56		1.55				
903020	0.14		0.38				
903031	0.20		0.54				
903039	0.57		1.55				
	100	100	100	100	100	100	100

ANNEX 2: DETAILED METHODOLOGY

This paper uses a detailed study of key technologies and components within the renewable energy supply sector that are available on a commercial basis, prepared by the Energy-research Centre of the Netherlands (ECN). Following the publication of this mapping study (Lako, 2008), Izaak Wind, former Deputy Director (Harmonized. System), World Customs Organization, has also tried to identify the 6-digit HS codes that correspond, as closely as possible, to the goods and components associated with these technologies (Table A1.1).

Identifying HS codes for these products and components is necessary but with very few exceptions, it is an insufficient first step in exploring the possible use of the information contained in the mapping study for an analysis of trade issues.

One well-known problem is that 6-digit HS codes are, by and large, defined much more broadly than the goods and components defined in the ECN mapping study. Therefore, unrelated products get included. Once RES technologies are assigned to a 6-digit HS code, trade analysis is based on trade in all items included in that code. In some cases, the implications of this for a trade analysis may be manageable, but in many, if not most other cases, this problem will be significant. In some cases, this may invalidate any attempt to draw conclusions with regard to trade issues associated with the deployment of renewable energy technologies and components.

The ECN list consists largely of components. Analyzing trade in components linked to a specific end-use sector (in this case renewable energy supply) tends to be complicated by the fact that the same component may be used by different end-use sectors.

This Annex discusses some classification issues and suggests some possible avenues to reduce data problems when applying the ECN list for future case studies. It uses more detailed tariff schedules and trade data from the US and the EU, the two largest import markets of RES goods and components

The ECN list of RES technologies includes distinct categories:

- Sub-categories and components that are exclusively used for RES (“single-use” products). These products are bio-ethanol, biodiesel, solar water heaters, PV modules and wind turbines. The most important issue that may arise here is the “ex-item” question, i.e. does the 6-digit HS code to be used for these products include other, unrelated products? In only one case, wind turbines, is the 6-digit HS code used exclusively for the RES product in question. In all other cases, unrelated products will be included. Thus, the question is: to what extent could this affect a trade analysis of RES products based on a 6-digit HS codes? This section tries to shed some light on this question based on more detailed tariff schedules used in the two largest import markets for RES products, i.e. the US (the 10-digit Harmonized Tariff Schedule (HTSUS) and the EU (the 8-digit Common Nomenclature (CN);
- Components that are used in the RES sector. These components have been assigned to 6-digit HS codes which normally also include products that are not linked to the RES sector (“multiple-use” products). The most important issue here is whether trade in these HS codes is, at least to a reasonable extent, driven by developments in the deployment of renewable energy technologies. Where exposure to the deployment of RES technologies is relatively low, including multiple-use products in an analysis of trade issues is difficult to justify. While HS codes sometimes indicate the end-use of products covered, renewable energy supply is not mentioned anywhere. Expert opinions are usually needed to help assess the extent to which imports and exports compiled from available trade statistics

(the 6-digit HS or even more detailed national or regional tariff schedules) may be linked to RES technologies and components. A technical analysis of tariff schedules alone may be of some help in some cases, but in most cases industry surveys will be needed. Surveys may help to narrow down the list of renewable energy products to a (probably small) number of key components. However, the results of these surveys may be case-specific.

Many RES and components are assigned to basket HS items (many HS code descriptions starting with "other" are basket items). Using such items may, in many cases, further affect the transparency of any trade analysis. Yet, even where there are no classification-related problems, multiple-use issues may make it difficult to carry out a meaningful trade analysis.

Case Study 1: Biodiesel

Biodiesel is included under HS code 382490, which also includes a very large range of unrelated chemical products and preparations. For most countries, biodiesel represents only a small part of trade under this 6-digit HS item. The US and the EU use more disaggregated tariff schedules which include specific tariff lines for biodiesel. This case-study seeks to learn some lessons from the use of these specific tariff lines rather than from the 6-digit HS code. It first examines global imports into these two markets. No disaggregated information was available on developing country imports of biodiesel. Therefore, this case-study analyzes US and EU exports to developing countries as an indicator for developing country imports of biodiesel. In 2008, around 20 percent of developing country imports under HS 382490 came from the EU and around 18 percent from the US. Imports from China and intra-developing countries trade were also significant.

Imports

In the US, the 10-digit HTSUS code for biodiesel is 3824904020. The US biodiesel imports have increased in recent years and in 2008 represented almost half of the value of all US imports under the provisions of HS 382490 (Table A2.1).

Table A2.1: US Imports of Biodiesel and Other Items Under HS382490, 2006–2008 (US$ Milllion)

	2006	2007	2008
HTSUS 3824904020	140.5	382.5	1364.1
HS 382490	1116.6	1471.1	2794.0
Share of biodiesel in imports under HS 382490 (%)	12.6	26.0	48.8

Source: Own elaboration based on data compiled from USITC, using the USITC Trade DataWeb.

Table A2.2 compares the listing of the top 20 foreign suppliers of all products under the provisions of HS 382490 with that of top suppliers of biodiesel (HS 3824904020). The tables show that the four largest foreign suppliers of biodiesel (Argentina, Indonesia, Malaysia and Singapore) are also among the 10 largest suppliers of the full range of products imported under the provisions of HS 382490. The latter, however, also includes a number of European countries and Japan which export chemical products and preparations other than biodiesel to the United States.

Table A2.2: Top Suppliers of Biodiesel and Items Under HS382490 to the US Market, 2006–2008

All US imports under the provisions of HS 382490 (US$million)					US Imports of biodiesel (HS 3824904020) (US$million)				
Source Country	2006	2007	2008	3-year average	Source Country	2006	2007	2008	3-year average
Argentina	0.2	34.1	772.7	269.0	Argentina	0.0	33.9	756.7	263.5
Canada	199.9	220.1	331.6	250.5	Indonesia	18.6	137.7	275.1	143.8
Indonesia	18.6	154.2	286.6	153.1	Malaysia	42.6	99.8	74.0	72.2
Germany	173.4	209.5	285.4	222.8	Singapore	2.6	25.5	111.1	46.4
China	104.6	105.8	181.8	130.7	Canada	16.0	28.7	92.0	45.6
France	80.5	92.6	118.1	97.1	Mexico	5.1	16.7	10.5	10.8
Singapore	4.1	26.9	114.6	48.5	Ecuador	26.3	5.5	0.0	10.6
Japan	106.8	99.9	110.9	105.9	Netherlands	9.8	8.5	10.4	9.6
United Kingdom	87.4	100.7	109.2	99.1	Norway	6.5	8.6	9.9	8.3
Malaysia	44.9	105.6	90.6	80.4	Germany	4.9	4.2	7.7	5.6
Netherlands	50.5	56.5	85.9	64.3	Belgium	4.7	3.2	5.7	4.5
Mexico	31.8	42.9	39.8	38.2	Australia	0.0	4.2	4.1	2.8
Switzerland	38.4	39.8	32.9	37.1	Sweden	1.4	1.9	1.7	1.7
Belgium	15.0	20.6	32.8	22.8	India	0.0	0.0	2.3	0.8
Korea	11.3	23.1	26.6	20.3	Japan	0.8	0.4	0.7	0.6
Italy	26.0	18.2	26.1	23.5	Italy	0.3	0.8	0.7	0.6
Liechtenstein	0.2	4.9	19.6	8.2	France	0.2	0.3	1.2	0.6
India	6.2	10.5	17.8	11.5	Brazil	0.0	1.6	0.0	0.5
Sweden	14.8	17.5	17.7	16.7	Korea	0.0	0.4	0.0	0.2
Spain	12.1	13.9	14.5	13.5	United Kingdom	0.3	0.1	0.0	0.1

Source: Own elaboration based on data compiled from USITC, using the USITC Trade DataWeb.

In the EU a separate code for biodiesel (HS 38249091) was introduced in January 2008. This code covers fatty-acid mono-alkyl esters (FAMAE). Some other forms of biodiesel could still enter the EU under other codes depending on the chemical composition. EU import statistics indicate that biodiesel imports under the provisions of HS 38249091 accounted for roughly 43 percent of total imports under the 6-digit HS 382490 code in 2008 (Table A2.3).

Table A2.3: EU–27 Imports of Biodiesel and Other Items Under HS 382490, 2008

HS 382490		CN 38249091 (biodiesel)	
Source Country	€ million	Country	€ million
United States	1666.6	United States	916.5
Switzerland	206.2	Indonesia	109.6
Indonesia	126.5	Argentina	57.8
China ,People's Republic of	125.0	Malaysia	25.9
Japan	119.2	India	7.1
Brazil	70.3	Japan	6.2
Argentina	69.2	United Arab Emirates	2.6
Malaysia	50.8	Canada	1.6
Norway	33.6	Norway	1.0
India	17.8	China ,People's Republic of	0.6
Turkey	15.0	Croatia	0.4
Canada	13.9	Singapore	0.3
Liechtenstein	12.6	Thailand	0.3
Korea ,Republic of	9.3	Switzerland	0.2
Total extra-EU total	2605.4	Total extra-EU	1130.2
Intra-EU	8604.9	Intra-EU	1813.5
Total EU-27 imports	11210.3	Total EU-27 imports	2943.7

Source: Own elaboration based on data compiled from EUROSTAT, using the EC export helpdesk.

The key third-country suppliers of biodiesel to the EU market (Argentina, Indonesia, Malaysia and the US) also appear under the top eight suppliers of all products covered in HS 382490. However, the latter also include a number of countries that largely supply other chemical products and preparations rather than biodiesel, in particular China, Japan and Switzerland.

Exports

While global US exports of biodiesel as a share of all US exports under HS 382490 has increased very significantly in recent years, the biodiesel share of US exports to developing countries has remained relatively stable at only 5-7 percent (Table A2.4).

Table A2.4: US Exports of Biodiesel and Other Items Under HS382490, 2006–2008 (US$million)

	2006	2007	2008
US exports to the world			
- HTSUS 3824904020	139.0	776.7	2633.1
- HS 382490	2222.9	2895.7	5085.2
- Share of biodiesel in exports under HS 382490 (%)	6.3	26.8	51.8
US exports to developing countries			
- HTSUS 3824904020	51.4	74.7	80.3
- HS 382490	971.9	1082.8	1371.8
- Share of biodiesel in exports under HS 382490 (%)	5.4	6.9	5.8

Source: Own elaboration based on data compiled from USITC, using the USITC Trade DataWeb.

In the case of the EU, 2008 exports of biodiesel represented less than two percent of exports of all products and preparations covered under HS 382490, and for EU exports to developing countries and emerging economies in Eurasia this share was only 0.6 percent.

Conclusions

If trade liberalization were implemented at the 6-digit HS level, biodiesel imports into the EU and US markets would be expected to benefit to a reasonable extent (along with imports of other chemical products and preparations). The availability of specific national and regional tariff lines for biodiesel makes it possible to analyze with some more precision how trade liberalization could boost imports of biodiesel into these markets. This would provide some transparency. In this context, biodiesel could be a meaningful “single-use” item. However, if developing countries were to liberalize imports at the 6-digit level, potential impacts on biodiesel imports would likely be very small (compared to other chemical products and preparations). In this context, biodiesel could not be considered as a meaningful “single-use” item at the 6-digit HS level.

This case study also shows that the extent to which it is possible to use specific tariff lines to better understand the possible implications of using 6-digit HS codes for analyzing trade in renewable energy products and technologies.

Case study 2: Wind Components

The second case study illustrates some issues related to the use of trade statistics for analyzing trade in components. It is based on a recent report by the United States USITC on wind turbines, which addresses trade and industry conditions for US wind turbine manufacturing for the period 2003 to 2008 (USITC, 2009).

The study considers only three groups of components: generators (HTSUS 8501.64.0020 AC generators with an output exceeding 750 kVA (kilovolt ampere), but not exceeding 10,000 kVA); towers (HTSUS 7308.20.0000); blades and other components (HTSUS 8412.90.9080 and 8503.00.9545). While acknowledging that these items still include components that are not used in wind turbines, the USITC report argues that “wind accounts for a significant portion of trade in each category and appears to be a major driver of import growth”. However, no similar analysis is made of US exports of these components “since wind exports represent a much smaller percentage of trade in these categories” (USITC, 2009).

In the particular case of US imports of wind components (as defined here), the value of imports that would result from estimating trade values at the 6-digit HS level rather than the more precise 10-digit HTSUS level would be “only” 60 percent higher. Since imports of wind components reportedly have grown significantly in recent years, the "margin of error" has become smaller over time. However, in the particular case of HTSUS 850300 this margin has become larger. This may suggest that sub-items other than 8503009545 have grown more rapidly (Table A2.5). Thus, the margin of error may become larger if any other sector included in the same 6-digit HTSUS code is very dynamic.

Table A2.5: US Imports of Wind Components, 2006–2008, 6–Digit HS Versus 10–Digit HTS Codes (US$ Milllion)

6-digit HS codes				10-digit HTSUS codes				Over-estimation (%)		
Item	Period			Item	Period			Period		
	2006	2007	2008		2006	2007	2008	2006	2007	2008
730820	247.7	578.7	944.4	7308200000	247.7	578.7	944.4	0.0	0.0	0.0
841290	435.0	873.0	1825.0	8412909080	142.8	495.9	1299.6	204.6	76.0	40.4
850164	225.0	561.2	825.4	8501640020	142.8	435.7	644.5	57.6	28.8	28.1
850300	1640.2	2009.2	1825.9	8503009545	685.4	840.2	497.9	139.3	139.1	266.7
Total	2547.9	4022.1	5420.7		1218.7	2350.5	3386.4	109.1	71.1	60.1

Source: Own elaboration based on data compiled from USITC, using the USITC Trade DataWeb.

The good news is that the list of 20 top foreign suppliers of these wind components does not seem to be very sensitive to whether 6-digit or 10-digit HTSUS are used (Table A2.6).

Table A2.6: US Imports of Selected Wind Components at 6 and 10–Digit HTS Levels, 2007–2008. Top 20 Foreign Suppliers Ranked by Value of 2008 Trade

6-digit			10-digit HTSUS		
Country	Imports (US$million)		Country	Imports (US$million)	
	2007	2008		2007	2008
China	335.7	622.5	Brazil	327.3	468.5
Germany	529.6	616.5	Denmark	293.9	454.9
Canada	411.2	569.3	Germany	385.4	437.8
Brazil	374.7	534.2	China	143.9	290.2
Mexico	467.0	519.4	Canada	137.0	264.3
Denmark	337.4	507.3	Mexico	186.0	259.4
Japan	232.2	320.3	Korea	108.2	251.1
Korea	174.5	310.5	Spain	363.7	251.0
Spain	372.5	285.7	Japan	77.1	157.5
United Kingdom	156.4	242.3	Indonesia	28.2	122.4
India	85.6	147.7	United Kingdom	44.8	104.3
Indonesia	31.7	128.4	India	51.8	104.2
France	71.7	94.9	Austria	0.9	21.1
Viet Nam	84.3	78.8	Taiwan	8.0	17.9
Italy	50.8	77.4	Australia	34.0	15.6
Czech Republic	26.5	42.3	France	11.0	14.9
Taiwan	26.7	35.8	Netherlands	13.6	14.6
Singapore	21.3	33.9	Italy	11.8	13.1
Austria	13.5	30.2	Sweden	8.4	12.3
Netherlands	27.7	27.5	Finland	4.7	6.9

Source: Own elaboration based on data compiled from USITC, using the USITC Trade DataWeb.

ANNEX 3: TRADE IN HYDRO, GEOTHERMAL, AND OCEAN ENERGY PRODUCTS AND COMPONENTS

Table A3.1: Hydro–Energy Technologies and Components, Exports in 2007

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
All	20009.1	All developing countries*	6546.8
China	2289.2	China	2289.2
Germany	2136.4	Mexico	1236.5
Italy	1292.1	Korea, Rep.	702.8
Mexico	1236.5	Turkey	534.0
United States	1181.2	Brazil	340.2
France	1020.3	India	285.9
Austria	948.3	Singapore	230.2
Japan	765.1	Thailand	191.4
Korea, Rep.	702.8	Taiwan, China	156.5
Belgium	691.0	Malaysia	125.2
United Kingdom	595.0	Colombia	119.2
Turkey	534.0	Viet Nam	82.4
Spain	480.7	South Africa	54.6
Canada	472.4	Argentina	36.7
Czech Republic	402.0	United Arab Emirates	27.0
Denmark	340.5	Tunisia	26.3
Brazil	340.2	Saudi Arabia	19.6
Poland	340.1	Hong Kong, China	15.3
Netherlands	322.4	Morocco	12.8
Sweden	319.9	Kazakhstan	7.6
EU-27 total	9992.7		
Intra-EU trade	5912.3		
EU-total (excl intra-EU trade)	4080.4		

** Includes countries in Eurasia.*

Table A3.2: Hydro–Energy Technologies and Components, Imports in 2007

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All	20111.7	All developing countries*	7697.0
United States	3312.2	Hong Kong, China	801.1
Germany	1138.1	China	630.4
Hong Kong, China	801.1	Saudi Arabia	614.0
France	749.2	United Arab Emirates	508.2
United Kingdom	740.9	Mexico	419.3
China	630.4	Malaysia	363.8
Saudi Arabia	614.0	Korea, Rep.	358.7

Table A3.2. ***Continued***

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
Spain	557.4	Singapore	348.8
Russian Federation	539.1	Viet Nam	275.0
United Arab Emirates	508.2	Thailand	257.6
Japan	473.6	Qatar	248.8
Canada	471.5	Turkey	246.2
Mexico	419.3	Brazil	190.1
Italy	399.2	Kazakhstan	185.6
Switzerland	370.2	India	174.1
Malaysia	363.8	Algeria	171.6
Korea, Rep.	358.7	South Africa	169.4
Singapore	348.8	Taiwan, China	135.3
Norway	343.7	Venezuela	115.2
Denmark	318.9	Oman	108.4
EU-27 total	6407.2		
Intra-EU trade	4667.6		
EU-total (excl intra-EU trade)	1739.7		

Includes countries in Eurasia.
Source: COMTRADE using WITS.

Table A3.3: Geothermal Energy Technologies and Components, Exports in 2007

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
All	22692.5	All developing countries*	4927.1
Germany	3058.7	China	2412.7
China	2412.7	Korea, Rep.	909.6
France	2198.4	Thailand	647.5
United States	1906.5	Mexico	275.7
Italy	1895.9	Singapore	208.4
Japan	1868.7	Malaysia	103.1
Sweden	1671.1	India	102.7
Korea, Rep.	909.6	Turkey	67.8
Thailand	647.5	Brazil	46.8
Czech Republic	593.9	Taiwan, China	40.5
Netherlands	543.0	Argentina	28.0
Spain	498.9	Saudi Arabia	22.0
Austria	493.9	Viet Nam	13.1
Switzerland	486.9	South Africa	12.2
Ireland	458.3	Jordan	9.9
United Kingdom	348.1	Bangladesh	3.9
Mexico	275.7	Philippines	3.5

Table A3.3. ***Continued***

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
Denmark	246.1	Kazakhstan	2.9
Belgium	219.6	Chile	2.2
Canada	211.8	Namibia	1.9
EU-27 total	12944.0		
Intra-EU trade	7798.9		
EU-total (excl intra-EU trade)	5145.1		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Table A3.4: Geothermal Energy Technologies and Components, Imports in 2007

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All	21084.9	All developing countries*	7840.8
Germany	1748.7	China	1547.1
China	1547.1	Thailand	810.7
United States	1462.6	Korea, Rep.	627.4
Russian Federation	1197.0	Saudi Arabia	599.4
France	980.7	Viet Nam	513.4
Italy	949.2	Qatar	403.3
Canada	844.8	Mexico	348.5
Thailand	810.7	Singapore	294.9
United Kingdom	664.3	United Arab Emirates	288.9
Korea, Rep.	627.4	India	285.6
Saudi Arabia	599.4	Malaysia	235.3
Netherlands	566.4	Turkey	205.1
Viet Nam	513.4	Kazakhstan	203.7
Japan	449.0	Taiwan, China	193.5
Spain	421.2	Brazil	142.3
Qatar	403.3	Argentina	124.9
Norway	395.0	South Africa	122.9
Belgium	369.9	Pakistan	92.0
Austria	349.0	Oman	63.3
Mexico	348.5	Venezuela	60.3
EU-27 total	7965.7		
Intra-EU trade	6279.3		
EU-total (excl intra-EU trade)	1686.4		

** Includes countries in Eurasia. Source: COMTRADE using WITS.*

Table A3.5: Ocean Energy Technologies and Components, Exports in 2007

Exporter (all)	Exports (US$million)	Exporter (developing countries)	Exports (US$million)
All	23425.2	All developing countries*	9580.0
China	2119.2	China	2119.2
United States	1938.0	Mexico	1882.8
Mexico	1882.8	Korea, Rep.	1234.5
Germany	1800.5	Turkey	712.9
Korea, Rep.	1234.5	Thailand	704.1
Italy	1113.7	Brazil	455.2
France	1006.7	India	359.0
Japan	741.2	Viet Nam	334.6
Turkey	712.9	Singapore	284.5
Thailand	704.1	Taiwan, China	265.1
Switzerland	679.6	Malaysia	259.9
Sweden	656.0	Saudi Arabia	146.2
Poland	548.2	Tunisia	132.2
Canada	487.1	Colombia	131.0
Spain	480.6	Morocco	106.3
Brazil	455.2	South Africa	98.0
Belgium	449.4	Syrian Arab Republic	89.1
Austria	406.5	Argentina	41.3
United Kingdom	371.7	Zambia	38.5
India	359.0	Oman	34.3
EU-27 total	8891.5		
Intra-EU trade	4781.5		
EU-total (excluding intra-EU trade)	4110.0		

** Includes countries in Eurasia.*
Source: COMTRADE using WITS.

Table A3.6: Ocean Energy Technologies and Components, Imports in 2007

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
All	25574.7	All developing countries*	12645.8
United States	2980.8	Mexico	1771.7
Mexico	1771.7	Saudi Arabia	947.3
Russian Federation	1132.1	Thailand	935.9
Germany	1058.2	United Arab Emirates	885.7
Saudi Arabia	947.3	China	824.3
United Kingdom	945.9	Hong Kong, China	777.7
Thailand	935.9	Viet Nam	603.8
United Arab Emirates	885.7	Korea, Rep.	595.0
Spain	828.4	India	427.7

Table A3.6. ***Continued***

Importer (all)	Imports (US$million)	Importer (developing countries)	Imports (US$million)
China	824.3	Kazakhstan	415.8
Hong Kong, China	777.7	Malaysia	405.8
Viet Nam	603.8	Qatar	342.7
Korea, Rep.	595.0	Singapore	304.5
Canada	592.6	Brazil	254.1
France	571.1	South Africa	232.3
Japan	460.2	Turkey	195.9
India	427.7	Pakistan	195.5
Kazakhstan	415.8	Morocco	186.0
Italy	411.0	Taiwan, China	164.9
Malaysia	405.8	Venezuela	146.8
EU-27 total	6431.0		
Intra-EU trade	4239.5		
EU-total (excl intra-EU trade)	2191.6		

Countries in Includes Eurasia.
Source: COMTRADE using WITS.

ANNEX 4: APPLIED AND BOUND TARIFFS FOR SELECTED "SINGLE-USE" PRODUCTS

Table A4.1: Applied and Bound Tariffs – HS 382490 (Includes Biodiesel)

Reporter	Imports in 2007 ($m)	Applied tariffs				Bound tariffs		
		Number of tariff lines	Average	Min	Max	Average	Min	Max
China	2840.2	4	4.0	0	6.5	30.0	30	30
EU-27	2397.8	20	4.6	0	6.5	4.6	0	6.5
Korea, Rep.	1880.1	45	6.4	2	8	6.5	5	6.5
Taiwan, China	1807.7	28	1.7	0	5	1.8	0	5
United States	1576.8	29	2.9	0	6.5	3.5	0	6.5
Japan	895.8	10	1.2	0	3.9	0.0	0	0
Mexico	681.6	76	7.2	0	10	35.0	35	35
Thailand	562.5	7	5.0	5	5	1.8	0	5
Canada	499.3	6	3.3	0	6.5	5.4	0	6.5
Switzerland	485.0	2	N.A.*	N.A.*	N.A.*	N.A.*	N.A.*	N.A.*
Hong Kong, China	466.4	20	0.0	0	0	4.6	0	6.5
Turkey	392.9	21	4.8	0	6.5	14.6	12	15
Russian Federation	381.2	14	5.0	5	5	N.A.*	N.A.*	N.A.*
Tariff average								
- Simple			3.8	1.0	5.8	9.8	7.5	11.1
- Trade-weighted			3.9	0.6	6.2	10.9	8.8	12.2

Source: COMTRADE, using WITS and WTO, using the WTO Tariff Download Facility.
** N.A. refers to cases where bound rates do not exist.*

Table A4.2: Applied and Bound Tariffs – HS 850231 (Wind Turbines)

Reporter	Imports in 2007 (U$mill.)	Applied tariffs				Bound tariffs		
		Number of tariff lines	Average	Min	Max	Average	Min	Max
United States	2,365.1	2	1.3	0	2.5	1.3	0	2.5
China	372.0	1	8.0	8	8	8.0	8	8
Australia	158.2	2	2.5	0	5	5.0	0	10
Taiwan, China	123.9	1	10.0	10	10	10.0	10	10
Canada	108.6	1	0.0	0	0	6.2	6.2	6.2
EU	98.2	1	2.7	2.7	2.7	2.7	2.7	2.7
Turkey	92.4	6	1.4	0	2.7	13.6	12.8	14
Japan	62.5	1	0.0	0	0	0.0	0	0
Brazil	42.3	1	0.0	0	0	35.0	35	35
Thailand	37.8	2	10.0	10	10	N.A	N.A.	N.A
Korea, Rep.	33.6	4	8.0	8	8	N.A	N.A	N.A
New Zealand	22.9	2	2.5	0	5	16.5	16.5	16.5

Table A4.2. ***Continued***

Reporter	Imports in 2007 (U$mill.)	Applied tariffs				Bound tariffs		
		Number of tariff lines	Average	Min	Max	Average	Min	Max
Mexico	17.1	2	10.0	0	20	37.5	35	40
Tariff average								
- Simple			4.3	3.0	5.7	12.3	11.5	13.2
- Trade-weighted			2.1	1.2	3.0	3.7	2.5	4.8

Source: COMTRADE, using WITS and WTO, using the WTO Tariff Download Facility.

Table A4.3: Applied and Bound Tariffs – HS 854140 (Includes Solar Panels)

Reporter	Imports in 2007 (US$mill.)	Applied tariffs				Bound tariffs		
		Year	Average	Min	Max	Average	Min	Max
EU-27	8496.1	2008	0.0	0	0	0.0	0	0
China	3288.6	2006	0.0	0	0	0.0	0	0
United States	2155.7	2008	0.0	0	0	0.0	0	0
Hong Kong, China	1817.5	2007	0.0	0	0	0.0	0	0
Korea, Rep.	1276.8	2007	0.0	0	0	0.0	0	0
Taiwan, China	544.4	2007	0.0	0	0	0.0	0	0
Singapore	503.6	2008	0.0	0	0	0.0	0	0
Mexico	442.5	2007	0.0	0	0	35.0	35	35
Malaysia	306.9	2001	0.0	0	0	0.0	0	0
Canada	202.5	2008	0.0	0	0	0.0	0	0
India	168.9	2008	0.0	0	0	0.0	0	0
Thailand	167.1	2007	0.0	0	0	0.0	0	0
South Africa	141.1	2007	0.0	0	0	10.0	10	10
Switzerland	115.7	2008	N.A.	N.A.	N.A.	0.0	0	0
Brazil	91.7	2008	4.4	0	12	20.6	0	35
Australia	83.7	2008	0.0	0	0	0.0	0	0
Israel	44.3	2006	0.0	0	0	0.0	0	0
Turkey	29.2	2006	0.0	0	0	0.0	0	0
Russian Federation	27.6	2001	20.0	20	20	N.A.	N.A.	N.A.
Philippines	23.3	2008	0.0	0	0	0.0	0	0
Croatia	17.7	2006	0.0	0	0	0.0	0	0
Norway	17.6	2008	0.0	0	0	0.0	0	0
Bangladesh	16.6	2005	13.0	13	13	N.A.	N.A.	N.A.
New Zealand	10.5	2008	0.0	0	0	0.0	0	0
Kenya	10.3	2005	0.0	0	0	N.A.	N.A.	N.A.

Table A4.3. ***Continued***

Reporter	Imports in 2007 (US$mill.)	Applied tariffs				Bound tariffs		
		Year	Average	Min	Max	Average	Min	Max
Tariff average								
- Simple			1.5	1.3	1.8	3.1	2.1	3.8
- Trade-weighted			0.02	0.00	0.06	0.95	0.85	1.01

Source: COMTRADE, using WITS and WTO, using the WTO Tariff Download Facility.

Trade data are based on COMTRADE, using WITS. Trade data are presented in descending order of 2007 import values and expressed in US$million. In this annex, data for the EU-27 exclude intra-EU trade.

Tariff data are extracted from WTO databases, using the WTO Tariff Download Facility. Data on applied tariffs come from the WTO Integrated Data Base (IDB), whereas bound rates come from the Consolidated Tariff Schedules (CTS) database covering all WTO members. Applied rates are shown for the most recent year available. In some cases, national or regional tariff schedules include more than one tariff line for a particular 6-digit HS code. For example, Mexico has 76 tariff lines for HS 382490. In this case, the minimum and maximum tariffs are listed under the "Min" (minimum) and "Max" (maximum) columns respectively. Bound rates correspond to the 1996 HS schedule.

The country names are those appearing in COMTRADE (except for "EU-27" which aggregates imports into the 27 EU Member States).

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