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Building Bridges for Climate Change Mitigation A Roadmap of Global Trade Patterns in Wind Power Goods and Services

by

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[*] The views expressed in this study are those of the author and do not necessarily reflect those of the OECD or of any of its Member governments. This document is not available for public distribution.

TABLE OF CONTENTS

BUILDING BRIDGES FOR CLIMATE CHANGE MITIGATION A ROADMAP OF GLOBAL TRADE PATTERNS IN WIND POWER GOODS AND SERVICES....3

- Twelve years of extraordinary growth....4
- Trade in wind power: the global context....5
- Stark disparity in deployment of wind power....7
- Wind-power investors' decision-making benchmarks for developing countries....9
- Additional findings....11
  - CDM provides additional financing but opportunities are not being fully exploited due to cumbersome registration process....11
  - U.S. tax incentives are considered a trade barrier by some wind-power investors....11
  - European market constrained by lack of harmonized support regime....12
  - Wind power's future depends on increased transmission capacity, grid integration technology, offshore power plants and slow-wind technology....12
- A composite sketch of wind-power developers operating in developing countries....13
- China becoming world's leading user and producer of wind power technology....16
- Conclusions....18

REFERENCES....20

BUILDING BRIDGES FOR CLIMATE CHANGE MITIGATION
A ROADMAP OF GLOBAL TRADE PATTERNS IN WIND POWER GOODS AND SERVICES

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1. Mitigating climate change will require rapid and widespread deployment of key technologies and practices ranging from end-user efficiency efficiency and low-carbon power in the energy supply sector to afforestation and improved land-management practices in the forestry and agriculture sectors. One of the greatest challenges lies in transitioning from the current carbon-intensive electric power supply to low-carbon generation sources such as natural gas, nuclear energy and renewable energy technologies such as wind, biomass and geothermal, as well as deploying carbon capture and storage to sequester carbon emissions first from coal power plants then from gas-fired power plants and carbon-intensive industries.

2. Renewable energy technologies will be particularly important for displacing the consumption of fossil fuels, which account for approximately 70% of global emissions of greenhouse gases (GHGs), according to the Intergovernmental Panel on Climate Change (IPCC). Yet even with strong recent growth in the generating capacity of wind power and solar photovoltaic (PV) power and the adoption of GHG-reduction policies in many OECD countries, emissions from fossil fuels increased every year from 2001 through 2006, according to the IPCC's Fourth Assessment Report. "Without the near-term introduction of supportive and effective policy actions by governments, energy related GHG emissions, mainly from fossil fuel combustion, are projected to rise by over 50% from 26.1 GtCO2eq (7.1 GtC) in 2004 to 37–40 GtCO2 (10.1–10.9 GtC) by 2030." (IEA, 2008; IPCC, 2007)

3. In terms of electricity supply, IPCC projects that renewable power resources, including hydropower, will be called upon to provide 50 percent of the GHG mitigation needed by 2030. To accomplish that, the pace of adoption of these technologies must be increased significantly, particularly in developing countries where the need for additional power is leading to massive growth of fossil-fuel based power generation (IPCC, 2007; Daniel, 2008).

4. Because the capacity to develop and manufacture renewable energy technology is not equally dispersed across nations—indeed, most countries manufacture no wind turbines or solar panels—trade in renewable energy technology is necessary for achieving its widespread deployment. Furthermore, the proficiency levels and cost structures of manufacturers vary greatly, both within countries and across borders, so trade in goods and intellectual property (IP) is necessary to ensure that the most efficient and cost-effective renewable-energy technologies are widely available. Additionally, the financial and technical expertise required to develop utility-scale renewable energy projects is concentrated in OECD countries (where government policies and high energy costs have created robust markets), hence trade in the services associated with renewable energy project development is needed in order to assist countries lacking such expertise.

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1. The views expressed in this study are those of the author and do not necessarily reflect those of the OECD or of any of its Member governments. The author wishes to express his appreciation for information and comments provided by Hugo Chandler, Joy Aeree Kim, and Ronald Steenblik. Any remaining errors and omissions is the responsibility of the author.

5. The objectives of this study are to examine patterns of trade in renewable energy technology and the services associated with project development, to explore how trade in these technologies takes place, including the business models and deal structures used by firms engaged in it, and to provide insights into policies and market conditions relevant to the future growth of renewable energy, particularly in developing countries.

6. Because wind power is the fastest growing segment of renewable power, with the largest installed capacity after hydropower, this study concentrates on that form of renewable energy with a focus on utility-scale generation. Many of the observations and insights herein will also relate to deployment of other technologies that provide utility-scale power, particularly biomass, geothermal and small-scale hydropower. This paper will be less relevant to Solar PV, which is usually installed as a small-scale distributed resource (REN21, 2008).

7. The author relied on interviews with 14 individuals who represent firms participating in the international wind-power market as project developers, wind turbine generator (WTG) manufacturers, technology developers, asset managers, investors, consulting engineers and other service providers. (Some firms fulfill multiple roles.) The author also drew on data and analyses from published research (see "References"), as well as other interviews with participants in the wind-power, solar PV, geothermal and concentrating solar thermal power sectors who were interviewed for concurrent research into non-tariff barriers (NTBs). With four exceptions, all the author's contacts were with people from OECD countries. By prior agreement, the individuals and their firms are not named, a policy that allowed them to discuss proprietary details of their international operations and to comment freely on the policies of foreign governments.

Twelve years of extraordinary growth

8. The wind-power industry has grown at an extremely rapid pace over the last 12 years. Total installed capacity of wind power worldwide has increased from 6,100 MW in 1996 to 120,791 MW in 2008, according to the Global Wind Energy Council (GWEC). In 2008, 27,056 MW of wind-power capacity was installed worldwide, a 28.7% annual rate of growth (GWEC, 2009) .

9. Wind power has not been immune to the global economic crisis. Project developers and suppliers face the same daunting obstacles as participants in other industries do, and some that are unique to renewable energy: financing is less available and more expensive; the decline in natural gas prices has increased fuel-switching from coal to gas in Europe, resulting in less demand and lower prices for Certified Emissions Reductions (CERs) to finance renewable-energy projects in developing countries; declining oil prices have reduced fuel costs for power generation in many developing countries, resulting in less demand for new wind-power generating capacity; and in the United States, tax incentives for utility-scale renewable energy projects have become much less effective in the wake of declining corporate profits. (The U.S. Administration's stimulus package seeks to address the shortage of current-year tax credit capacity with a grant-in-lieu-of-tax credit provision.)

10. At the same, the overall downturn in economic growth has reduced the prices of WTGs and increased the availability of engineering, procurement and construction (EPC) services as well as heavy equipment such as cranes. According to the International Energy Agency (IEA), high demand had driven up WTG prices by 20 to 80 percent from 2004 to 2006. Said one wind-power developer: "Now the leverage has swung back to the buyers' side as opposed to the sellers', and we will start to see prices come down" (IEA, 2008).

11. It is beyond the scope of this paper to analyze how the economic crisis will affect the wind energy sector's growth in 2009 and 2010, how economic recovery will impact the wind-power industry, or

whether the industry will return to or even exceed its 2008 growth in installed capacity. The business models, market conditions, trade and policy issues discussed herein are based on recent historic patterns of the wind-power industry's development prior to the crisis.

Trade in wind power: the global context

12. The wind-power industry has always been highly dependent on trade, both in WTGs, associated components and IP. More recently, trade in the services associated with developing wind-power facilities, often called wind farms, has figured more prominently in global wind-power growth.

13. The modern wind-power industry emerged in the late 1970s after oil-supply shocks dramatized the need for new renewable energy sources. The United States, Denmark and other OECD countries funded WTG research and development and created incentives to subsidize the construction of wind farms. One of the first robust commercial markets emerged in California, where generous federal and state tax credits created a wind-power boom beginning about 1980. The boom ended precipitously in 1986 after the tax credits lapsed. When the dust from the wind "gold rush" settled, it became apparent that the incentives had led to some wind farms being developed in an inefficient manner, resulting in lower than anticipated electricity production, high technical failure rates and bankruptcy for some wind-power market participants. The fledging wind-power industry then endured a difficult restructuring period. Going forward, the California experience underscored the need for more reliable wind resource analysis, and wind meteorology started to shift from an academic discipline to a core business competency for the wind-power industry (Petersen, 1997).

14. The central role of trade and foreign direct investment (FDI) in the development of the wind-power industry can be seen vividly in the history of Vestas (Denmark), the world's largest WTG manufacturer. According to information on the company's website, after Vestas recovered from its losses in California, its first large foreign transactions were with buyers in India, where it founded a subsidiary and supplied six aid-financed wind farms. Through 1997, Vestas went on to establish a German subsidiary, made very large sales to wind farms in California and the United Kingdom, founded a subsidiary in Sweden, formed the Gamesa Eolica S.A. joint venture with Spanish WTG manufacturer Gamesa and made its first sales to China. Vestas also did a growing business in its home market, where wind farm co-operatives received favourable tax incentives. By 1997, approximately 1,000 MW of wind-power generating capacity was installed in Denmark (Danish Wind Power Association, 1997).

15. Over the next decade, Vestas' international trade and investment activities grew apace with its own sales and the wind-power industry as a whole. Highlights included: founding a subsidiary in Italy; signing a distribution agreement with a Japanese firm; making its first sales to Costa Rica and Iran; selling its holdings in Gamesa Eolica; opening production facilities in Scotland, Germany, Australia and China; and receiving very large orders from buyers in Australia, China, Egypt, France, Italy, New Zealand, Turkey and the United States. In 2008, Vestas reported that it employed 20,829 people in 27 countries, and that 40 percent of its revenue came from outside the Euro zone (Vestas, 2008).

16. Vestas procures goods from foreign suppliers, some of which provide vital components in the company's supply chain. With the rapid growth of wind power in recent years, the availability of components has become more critical, and Vestas has entered into collaborative framework agreements and development initiatives with suppliers for key components. The company expects to increasingly seek supplier relationships with vendors in the United States and China (Vestas, 2008).

17. While Vestas operates on a much larger scale than most WTG manufacturers, the role of trade and FDI in its business model can be seen as emblematic of the extent to which the wind-power industry is internationally integrated. WTG manufacturers source globally, from electrical components and

composites to bearings, blades, towers and gearboxes, and firms up and down the supply chain compete globally. The WTG manufacturing sector, including suppliers, has experienced a high level of consolidation over the last 10 years, with numerous mergers and acquisitions, many of an international character.

18. WTG manufacturers also trade services through licensing or acquiring IP associated with advanced WTG technology. An example of the importance of this trade can be seen in India's two largest WTG manufacturers, Suzlon and Global Wind Power (GWP). Both have invested heavily in European firms providing IP. Suzlon, the fourth-largest WTG manufacturer with 7% share of the global market in 2008, owns or operates facilities for technology innovation in Denmark, aerodynamic development in the Netherlands, and composite wind WTG technology in Germany. GWP has licensed WTG technology from Norwin (Denmark), Fuhrländer (Germany) and Lagerwey Wind (The Netherlands) (*Climate Change Business Journal*, 2008; de Vries, 2008; Emerging Energy Research, 2009).

19. For WTG manufacturers and their suppliers located in OECD countries, competition comes increasingly from firms operating in lower-cost countries, especially China. A source for this paper reported that, in 2004, China had only one domestic WTG manufacturer—Goldwind. By the end of 2008, there were approximately 60, with Goldwind as the leading seller, followed by Sinovel, Dongfang and Windey. Over the same period, the WTG supplier sector in China has also grown significantly. As discussed below, the growth of WTG manufacturing capacity in China has been driven by the domestic demand created by national energy policies and incentives. (Emerging Energy Research, 2009).

20. WTG manufacturers are the first component in the global wind-power value chain. To deploy WTG technology and generate electricity, two other sectors are critically important: developers and owners. In broad strokes, developers plan, engineer and build wind farms, while owners invest in wind farms and earn ongoing revenues from power production. Depending on company business models and market conditions, the three sectors are integrated to varying degrees. Some WTG manufacturers—notably, Suzlon, GWP and Acciona (Spain)—are also developers. Some developers have a supply agreement with one manufacturer, while others procure WTGs from many manufacturers. Many developers seek to turn over—or "flip"—projects to investors as soon as possible, while the business model of others emphasizes long-term ownership and operation as independent power producers (IPPs).

21. International wind-power project developers can be broadly divided into two classes of firms: diversified energy companies and independent developers of renewable energy projects. For European energy companies such as Iberdrola (Spain), E.On (Germany), EDP Energia de Portugal and EDF Energies Nouvelle (France), expansion into foreign markets for wind power has been a key growth strategy. These and other large developers have acquired many formerly independent developers in other OECD countries.

22. Many diversified energy companies are also wind farm owners. For example, Enel (Italy) owns renewable power facilities in Europe, North America, Central America and South America. Its U.S. subsidiary owns and operates a growing portfolio of wind farms in that country. Other owners include IPPs, investor- and state-owned utilities, private equity firms, and financial institutions and individuals seeking the tax benefits conferred by subsidy regimes in some countries.

23. For internationally active developers, their business models vary depending on the regions in which they are operating. A European energy company reported that after building projects in its home country, it targeted the United Kingdom, Spain and Portugal—markets growing quickly based on renewable energy targets, preferential feed-in tariffs (FITs) or tradeable green certificates (TGCs). As its foreign businesses grew and matured, the firm acquired or founded subsidiary companies. It followed the same pattern in Italy and Poland and expects to continue this model in Eastern Europe and possibly Turkey and North Africa. The firm structures its development activities through consortia, joint ventures and

framework agreements with other energy companies; strategic investments in renewable energy technology companies; and by investing in projects already in development.

24. Wind-power developers working in developing countries operate in very different conditions and deploy divergent strategies to meet those conditions. (For more on this subject, see the section, "A composite sketch of wind-power developers operating in developing countries", below.)

25. The major steps in developing a wind farm comprise:

- site prospecting and feasibility studies;
- designing the layout of WTGs and modeling electricity production;
- negotiating power-purchase agreements with wholesale electricity customers;
- performing environmental assessments;
- obtaining administrative approvals and grid connections;
- securing project financing and long-term investment;
- procuring and importing WTGs and related equipment;
- engineering and constructing the wind farm;
- and operating and maintaining the wind farm.

Depending on their internal expertise and capacity, as well as certain market conditions, developers accomplish these steps with a mix of their own resources and contractors. In many cases, an engineering, procurement and construction (EPC) firm manages the overall project, hiring subcontractors and guaranteeing performance. In other cases, firm staff or consultants acting as "owner's engineer" manage these functions. Three of the leading EPC firms in the wind-power industry are global consultancies Sinclair Knight Merz (Australia), Garrad Hassan (United Kingdom) and Parsons Brinckerhoff (United Kingdom).

26. Wind energy is not widely traded from country to country. As noted below under "Additional findings", wind-generated electricity is often physically transmitted across European borders, but the producers receive market rates rather than preferential FITs or TGCs. Wind-power market participants interviewed for this study believe that a harmonized EU-wide support system for wind power and other renewable technologies would lead to more economically efficient deployment of power generation facilities based on available resources without regard to borders. It must be noted, however, that restructuring current renewable-energy support mechanisms may raise the risk profile of European renewable energy projects in the eyes of investors.

27. In short, the wind-power industry, though not trade in wind-generated electricity, is highly globalized. The geographic diversity of manufacturers, suppliers and service providers can be seen vividly at industry trade shows. For example, more than 6,000 participants from 80 countries attended the 2009 European Wind Energy Conference and Exhibition in Marseille.

Stark disparity in deployment of wind power

28. As the data on installed capacity shows, however, wind-power generating capacity is concentrated in certain OECD countries and a handful of Asian nations (Table 1). Most developing countries produce no utility-scale electrical power from WTGs. Some developing countries that initiated wind-power development with favourable policies within the last 15 years have not been able to achieve consistent growth of their wind-power sectors. GWEC reports that in 2008, no Latin American or Caribbean countries except Brazil (94 MW) installed new utility-scale wind-power capacity; and in 2007,

only Brazil, Argentina and Chile installed new capacity (30 MW total). In Africa, there is virtually no wind-power electrical generating capacity outside of Morocco (134 MW) and Tunisia (54 MW). Outside of China (12,210 MW), India (9,645 MW), Japan (1,880 MW), Chinese Taipei (358 MW), South Korea (236 MW) and the Philippines (33 MW), Asian countries had installed a total of only 6 MW through 2008 (GWEC, 2007; GWEC, 2008).

29. While not all developing countries are endowed with sufficient wind resources for commercial wind-power generation, the disparity in the geography of wind-power deployment points to enormous potential for growth in developing countries. How to accelerate that growth has been the subject of much study in recent years, particularly as the energy needs of developing countries has led to a rapid expansion of their coal-based generating capacity.

30. Much discussion in multilateral fora about how to accelerate deployment of renewable energy in developing countries has focused on reducing or eliminating obstacles imposed by non-tariff trade barriers (NTBs). Several wind-power industry participants interviewed for this study highlighted NTBs in relation to certain developing countries. However, with the exception of alleged discrimination against foreign independent power producers (IPPs) in Malaysia and Indonesia (see "Wind power investors' decision-making benchmarks for developing countries", below), NTBs appear to be relatively insignificant barriers for most firms.

Table 1. Worldwide installed wind-power capacity as of the end of 2008

	MW	% of total
Europe	65,946	54.6%
North America	27,539	22.8%
Asia *	24,368	20.2%
Pacific Region (Aus, NZ)	1,644	1.4%
Africa & Middle East **	669	0.6%
Latin America & Caribbean ***	625	0.5%
Total	120,791	

* 97.4% of Asian capacity is in China, India and Japan.
** 75% of African and Middle Eastern capacity is in Egypt and Morocco.
*** 79% of capacity in Latin America and the Caribbean is in Brazil, Mexico and Costa Rica.
Source: Global Wind Energy Council, Global Installed Wind-power Capacity, 2008.

31. Many of the experiences reported with NTBs were one-time occurrences—such as a heavy-handed request for more local ownership of a project by officials in Nigeria, or a delay in receiving approvals to ship WTGs from China. The most commonly reported NTBs were redundant technical standards and certification regimes, but these were cited as problems not so much in developing countries as in the United States, Canada, the United Kingdom and other European countries. (Some industry participants consider the tax-incentive regimes in the United States and the restrictions on inter-state trading of subsidized renewable electricity in Europe to be indirect trade barriers. As explained in "Additional findings" below, these policy measures affect domestic investors equally, although recent U.S. legislation may have tilted its tax incentive programme against foreign investors.)

32. Many firms averred that inadequate IP protection and local content requirements in China constituted major or prohibitive NTBs. However, several other firms reported doing business successfully in China (see "China becoming world's leading user and producer of wind power technology" below). By the same token, some firms reported an aversion to South Asian countries due to difficulties repatriating revenues or dealing with requests for informal additional payments. Yet, a wind-power developer active in those same countries reported that handling repatriation procedures was "just a hurdle you have to

overcome. As long as you're aware of it and get the right bank and government official to sign off, it's not a problem." This same developer said his firm eschews mature wind-power markets in OECD countries to focus on what he called "dodgy" countries with higher levels of political risk and corruption.

33. To put it simply, NTBs often represent competitive advantages for firms that can successfully adapt to the business norms and conditions in developing countries. A perceived NTB for one firm is an opportunity to trade for another.

34. NTBs may have even less impact on other renewable energy technologies such as biomass, run-of-river hydropower and even geothermal, since much of the equipment required for those technologies can be procured or manufactured locally or in nearby countries. The representative for an EPC firm that builds conventional and renewable power projects said: "I suspect wind is more affected than some of the other renewable technologies. Small hydro and geothermal could probably be manufactured and designed locally therefore avoiding many of the import issues." And the representative for a European power company that invests in many types of renewable power projects said: "My observation is that developing countries are able to produce biomass and hydropower equipment before they can do so for wind projects."

35. Two qualifying points must be added, however. First, the individuals interviewed for this study work for firms that have targeted foreign markets based on features that make those markets attractive, such as high energy prices and government policies and incentives supporting renewable energy. Companies seeking to do business in countries with lower levels of government commitment to renewable power may indeed encounter major and prohibitive NTBs. Second, the current economic crisis may increase the severity of NTBs for wind power. One wind-power developer reported that his firm may abandon a project in a South Asian country because requests for informal additional payments and greater local ownership have increased in the wake of the crisis.

36. But in overall terms, research conducted for this paper reinforces some of the conclusions drawn by other researchers: that a developing country's imports and deployment of renewable energy technology is directly correlated with its gross domestic product (GDP), its energy policies, the structure and pricing of its electricity markets, its financial capacity to subsidize the up-front investment costs of renewable energy and other domestic policies and market factors. While the reduction or elimination of NTBs (not to mention tariffs) would decrease the marginal cost of deploying wind power in some countries, such trade obstacles do not constitute the major barriers; rather, internal policy measures and market conditions do (Cosbey et al., 2008; IEA, 2008; Jha, 2008).

37. The effectiveness of policy measures adapted in OECD countries varies widely. For onshore wind power, the IEA found that FITs in Germany, Spain, Denmark and Portugal were the most effective policy measures due to high investment stability and low administrative barriers. The United Kingdom, Italy and Belgium were judged to have less effective policies—renewable energy standards (quota) coupled with TGCs—even though remuneration levels were higher. This counterintuitive result was likely due to the presence of non-economic barriers and problems with the design of TGC systems that caused higher investor risk premiums (IEA, 2008).

38. However, as reflected in Table 1, the greatest disparities in policy effectiveness and resulting deployment of wind power exist between developed and developing countries.

Wind-power investors' decision-making benchmarks for developing countries

39. In fledgling or nascent wind-power markets, the ability of foreign developers to enter is critically important. Developing a wind farm is a far different enterprise than building a conventional generating plant fired by coal, natural gas or oil. The most fundamental difference is the much higher up-front

investment cost compared with conventional fossil-based power. Wind-power developers working in developing countries can face financial and regulatory risks that are much less common in OECD countries. (See "A composite sketch of wind-power developers operating in developing countries" below.)

40. Wind-power developers and other sources reported that they investigate the following factors when deciding whether to enter a developing country where the wind-power industry is immature or non-existent. Their observations correspond with those in the literature cited in this report.

- *Have electricity markets been opened to the extent that independent power producers (IPPs) can effectively negotiate power purchase agreements (PPAs) with utilities?* Even if a country's electricity market has been opened by legislation, developers seek to know if it is truly open or if state-owned utilities still resist dealing with IPPs, especially foreign-owned ones, either through unspoken policies to protect domestic power generators or through bureaucratic delays and corruption. Several respondents reported that state-owned power companies in Malaysia and Indonesia impose such obstacles to IPPs seeking to do business there.

- *Have the grid connections and power (PPAs negotiated by other foreign-owned IPPs been honored?* Developers reported that they are aware of instances in which foreign energy companies have invested in fossil power plants, only to lose large sums of money when government entities refused to honour agreements. In countries without transparent and independent judicial systems, legal recourse can be difficult or impossible to achieve.

- *Are there preferential rates for wind-generated electricity? Or are market power prices in the country high enough to justify wind-power projects?* The IEA reports that power costs in 2007 for onshore wind farms with high to medium quality wind resources ranged from USD 75 per MWh to USD 97 per MWh. By contrast, wholesale power prices in the European Union averaged € 44 (USD 60) in 2007 (Rademaekers, K., et al, 2008). In Europe, the higher costs of wind-generated power are compensated by preferential FITs and TGCs. But few developing countries can afford such incentives, so the market price of power becomes a key factor in making a wind farm viable. Said one developer: "If you're not in the market with your generating costs, nothing will work."

41. Developing countries that rely heavily on coal for electric power typically have relatively low power prices and consequently more political resistance to high-priced wind power. An energy analyst from South Africa, where there is less than 10 MW of wind power deployed, reported that the government's intention to create preferential FITs for renewable energy has been forestalled by stakeholder concerns over power prices. "Even with recent increases in the price of coal, our power tariffs are still quite low. An internationally competitive tariff for renewable energy would be ridiculously high for South Africa."

42. On the other hand, countries dependent on imported oil for a large percentage of their electrical generation have high power prices and a strong incentive to develop wind power and other forms of renewable energy. One developer reported that wind-power projects in Pakistan, which depended on oil for 29% of its electricity in 2006 according to the IEA, can receive wholesale power prices of between USD 120 to USD 130 per MWh. A consulting engineer reported that Caribbean nations are particularly dependent on oil for power, and that combined with their small electrical demands, they are well positioned to use wind power.

43. However, subsidies for imported fuel artificially reduce power prices in many countries.

Additional findings

CDM provides additional financing but opportunities are not being fully exploited due to cumbersome registration process

44. Interviewees reported that the revenues derived from sale of CERs are essential to the economic viability of wind-power projects in most developing countries. A wind-power developer with experience in Southeast Asia, South Asia and South America stated: "It would be fair to say that without CERs or other carbon offset incentives, it is impossible to create economically viable projects" in those regions. As noted above, market prices for CERs in early 2009 were so depressed by the economic crisis that there was little current incentive to develop projects with CDM financing. When CER prices recover, project developers and other wind-industry participants expect such carbon financing to again take a central role in supporting renewable-energy projects in developing countries.

45. But a European power company active in CDM financing reported that the CDM executive board's internal processes are inefficient and cumbersome. "When you try to develop a CDM project, it takes one-and-a-half years to get it registered." Improvements in the board's functioning could accelerate deployment of wind and other renewable energy technologies significantly, in this source's opinion.

46. He recommended that more designated operational entities (DOEs) be accredited by the executive board (all communication with the board must go through DOEs). A shortage of existing DOEs is creating a "bottleneck" in project registration. "You have to wait not only for the registration with the executive board, but you also have to wait to get resources at the DOEs." This individual acknowledged that the CDM executive board is aware of these problems and is short of funding and staff to accomplish restructuring. "If these managerial problems could be solved by the executive board or by the UNFCCC in general, there will be more project development activity when the CER prices recover."

U.S. tax incentives are considered a trade barrier by some wind-power investors

47. Several industry participants alleged that tax incentives for renewable energy generators in the United States make it difficult or impossible for foreign wind-power project developers to enter the U.S. market because they have no tax liabilities from which they can derive value from tax credits or accelerated depreciation. By contrast, preferential FITs and TGCs in Europe, China and elsewhere provide comparable incentives to foreign and domestic firms.

48. A Canadian energy company seeking to develop wind farms in the United States reported that to business in that country it must abandon its core business model and shift to a less attractive structure in which it develops projects to sell to tax-credit investors. "Every other part of my company develops, owns and operates assets. We just can't make the economics of wind projects in the United States work." This contact said that the lightly traded U.S. market for TGCs (called green tags or renewable energy certificates in the United States) provides little value, especially compared with TGC markets in Italy, Belgium and the United Kingdom, where demand is supported by GHG caps and renewable energy standards or quotas (IEA, 2008).

49. It should be pointed out that domestic U.S. firms also face limitations with the tax-incentive regime. Because only large financial institutions can efficiently monetize the tax incentives, developers typically sell wind farms to such tax-credit investors, losing a significant amount of potential revenues that a FIT or TGC regime would provide.

50. In 2008, however, U.S. federal law was changed to allow investor-owned utilities to qualify for renewable-energy investment tax credits of 30%. This has made it more favourable for U.S. utilities to develop, own and operate wind farms—while no comparable advantage exists for foreign utilities and

independent energy companies. Additionally, as of March 2009, it was not clear whether the recently enacted grant-in-lieu-of-tax credit provision, which was designed to provide incentives for renewable energy project developers independent of current-year tax liabilities (lacking in the current depressed economy), will be available to foreign entities.

European market constrained by lack of harmonized support regime

51. Several WTG manufacturers and wind-power developers active in Europe regard the national restrictions on cross-border transmission of renewably generated electricity as an indirect trade barrier that impedes the growth of wind power and other renewable energy technologies in Europe. While renewably generated electricity is often physically transmitted across European borders, exporters receive market rates rather than a preferential FIT or TGC. Only a German wind, solar or biomass producer, for example, can receive the German FITs for those technologies. Industry sources believe that a harmonized EU-wide support system for wind power and other renewable technologies would lead to more economically efficient deployment of power generation facilities based on available resources without regard to borders.

52. Such an EU-wide harmonization of support programmes for renewable energy has been considered by the European Commission (EC), which concluded in December 2005 that it was "too early" to compare the relative merits of national renewable-energy support programmes and design an EU-wide programme. The European Wind Energy Association agreed, and argued in December 2008 that the EC's conclusions were still valid. "A hasty move towards a harmonized EU-wide payment mechanism for renewable electricity would put European leadership in wind-power technology and other renewables at risk. Changes in frameworks always create uncertainty and have to be based on sound knowledge and well-proven tools" (EWEA website).

53. Wind-power representatives interviewed for this paper countered that the potential benefits would outweigh the risks. If accompanied by a large expansion of trans-European high-voltage transmission capacity, wind and other renewable energy resources could be deployed at a faster pace. Along with representatives of firms in the emerging concentrating solar thermal power (CSTP) industry, wind-power industry sources also recommend that North African renewable-energy generators qualify for European FITs or TGCs. Said one: "On a macro scale, Europe could lower its dependence on oil and gas by establishing a third source of energy: renewable power coming from the deserts of North Africa and the Middle East."

Wind power's future depends on increased transmission capacity, grid integration technology, offshore power plants and slow-wind technology

54. Greater transmission access is needed to deploy more wind power in many countries. A large international WTG manufacturer reported: "Expansion of existing grid infrastructure and transmission lines are key issues in the United States and in China, and in most other markets globally. Grids have traditionally been built to take in energy from conventional energy sources, and in many instances grid connections are non-existent where the good wind sites are. This may explain why some markets have experienced no installment of wind turbines at all. Reinforcement of already existing grid infrastructures and priority access for wind energy to the grids are also prerequisites for continued growth in more mature markets – governments need to plan and act now if they are serious about combating climate change and reaching their renewable targets by 2020."

55. In European countries that already meet a large proportion of electricity demand with wind power, future growth of wind power will have to be facilitated by grid management strategies to handle the intermittency of wind energy. While wind-heavy electricity networks can be balanced with conventional power resources and sophisticated transmission controls, electricity storage technology may also be needed

to store wind-generated electricity when wind generation is high but demand is low, and then dispatch that power to the grid when demand is high. Energy storage technology such as advanced batteries and flywheels are being tested with this goal in mind. One advanced demonstration project is underway between the Danish utility Dong Energy and the U.S. firm Better Place. The joint venture aims to deploy electric vehicles in Denmark and use them as a distributed energy-storage resource. The project would include advanced charging systems, power electronics and so-called "smartgrid" technology to facilitate two-way power flow from homes (*Climate Change Business Journal*, November 2008).

56. Another challenge to future wind-power development in Europe is the fact that, in Germany, the United Kingdom, Denmark and the other Nordic countries, onshore wind-power sites are constrained and large additions of future wind capacity must be developed offshore. At the present time, only two WTG vendors—Siemens and Vestas—have significant experience supplying offshore wind projects. Additionally, there is a reported shortage of vessels capable of installing offshore wind facilities (*Climate Change Business Journal*, 2008).

57. Finally, as noted by the IEA and others, onshore wind energy developers have concentrated on the best wind resource sites within feasible proximity to transmission grids. "A good-wind-speed site for an average development is around 7m/s (25 kmph, 16mph) and above, at a hub height of around 80 metres." To build the global capacity of wind power to the levels required to achieve significant GHG mitigation, more and more onshore development will have to occur at sites with medium to low-quality wind resources. And achieving cost-effective generation on such sites will require technological refinement and innovation (IEA, 2008).

58. Said one asset management firm engaged in operating and maintaining wind farms: "As we go forward, the less attractive sites will have to be brought online. To do that, we'll need new technology to maximize the power output" from WTGs operating on sites with lower average wind speeds. "A lot of work is being done on the technology of blade efficiency, with the object of reducing the wind speed needed to get peak output. These and other innovations represent the natural evolution of the wind-power industry going forward."

A composite sketch of wind-power developers operating in developing countries

59. To characterize how trade in the services associated with wind-power development actually occurs, the author conducted confidential interviews with three wind-power project developers active in developing countries. They included two independent wind-power developers and a European power company that invests in renewable energy projects in developing countries through the Clean Development Mechanism (CDM). Additionally, executives with WTG manufacturing companies, consultancies and other participants in the wind-power market provided relevant insights into patterns of trade in wind-power-related services with developing countries.

60. Wind-power developers active anywhere in the world have to manage a variety of technical, financial and environmental risks to protect investors and secure credit. Third-party verification services are required to quantify wind resources and validate wind farm designs; warranties and performance guarantees are needed from WTG suppliers and EPC firms; environmental assessments must be rigorously performed to identify any impacts on ecosystems, plant and animal resources, especially rare or endangered species.

61. However, wind-power developers working in developing countries often face additional risks that are much less common in OECD countries: risks that contracts with partners, suppliers and customers will not be honored, with no reliable recourse from judicial systems; risks that IP will be compromised; risks that project approvals will not be forthcoming unless bribes are paid; risks that regulators will change their

interpretations of the energy policies affecting a project that the developer is working on; and risks that political instability will lead to changes in government treatment of foreign enterprises or even expropriation of property (Cosbey, 2008).

62. One of the two independent developers described its strategy for managing such risks in China, a country avoided by some firms—including the other independent developer interviewed for this paper—because of concerns over contract enforcement and regulatory uncertainty. By forming joint ventures with reliable partners—with ownership limited to 49% in accordance with Chinese law—this developer has had no issues with its contractual obligations being honored. The expertise and contacts of its Chinese partners has also conferred important advantages. For example, due to national policy, China's state-owned banks offer more favourable terms for wind-power projects than international banks. "Working through our relationships, we've gotten very good terms with little complexity from local banks."

63. "Our strategy from the beginning clearly involved finding the right local partners. We'd bring in the technical, commercial and project management expertise while they'd handle the local issues like securing rights to the site, obtaining project approvals and other functions that require local knowledge. Others have said 'China is too difficult; we're not going there.' We've found ways to address the risk issues through the selection of the right counterparties and JV [joint venture] partners."

Table 2. Wind-power Project Development: Where are Services Procured?

Three approaches used by companies working in developing countries

1 = Procured locally; 2 = Procured internationally; 3 = Provided by local partners; 4 = Provided by firm's staff	Wind Project Developer A	Wind Project Developer B	Energy Co. Investing in CDM-financed Wind Projects
1) Identify project opportunities, sites and electricity customers.	3, 4	3, 4	1, 2
2) Assess wind resources.	4, 1	1, 2	1, 2
3) Acquire or lease sites.	3, 4	1	1
4) Plan and engineer grid interconnection,	1, 4	4, 2	1, 2
5) Preliminary design and engineering of project with cost estimates,	1, 4	4	1, 2
6) Negotiate power purchase agreement with end-use customer,	3	4	1
7) Manage environmental analyses, permitting and approval processes.	3, 4	1, 4	1
8) Secure project construction financing.	3, 4	4	4
9) Final design and engineering.	1, 4	2, 1	1, 2
10) Secure long-term financing.	3, 4	4	4
11) Procure and import equipment.	3, 4	4, 2	4, 1

1 = Procured locally; 2 = Procured internationally; 3 = Provided by local partners; 4 = Provided by firm's staff	Wind Project Developer A	Wind Project Developer B	Energy Co. Investing in CDM-financed Wind Projects
12) Install equipment and construct project.	3, 4	2	1
13) Overall project, management and monitoring.	3, 4	4	4

Note: where number order is reversed (e.g., "4, 2" this indicates that the first listed party takes primary responsibility.

64. However, this developer is facing an increasing degree of regulatory uncertainty in China. As described in the section "China becoming world's leading user and producer of wind power technology", favourable policies for foreign-Chinese joint ventures in wind power have shifted recently to favour wholly owned Chinese firms. A WTG manufacturer operating in China said that a particular challenge of doing business there is that laws and regulations tend to leave a lot of room for interpretation in enforcement. "You only find out the implications after you've already begun to operate. You learn about them in dialogue with Chinese associates and in day-to-day business. There is a kind of insecurity that regulators may use their discretion to favour domestic suppliers. Because regulations are written in a general way, this kind of treatment can be very difficult to document."

65. The other independent developer reported that his firm's business in South Asia and South America is also based on partnerships with reliable local firms. "We don't just fly off to some obscure place in Asia. We work with locals who have already identified the sites. We come in and help out with development and financing." When this firm enters new markets, it often works with international engineering companies, law firms and banks already established in the country to obtain local expertise and contacts. It also considers purchasing political risk insurance. Providers of such insurance use country-risk classifications developed by the OECD and the Fitch sovereign ratings system, according to the International Institute for Sustainable Development (IISD). In countries with the highest political risk it can be difficult or extraordinarily expensive to obtain political risk insurance (Cosbey et al., 2008).

66. For the European power company developing CDM-financed projects, a key risk factor to be managed is ensuring that projects actually deliver the CERs that it purchases. The firm participates in the CDM marketplace both by buying CERs from project owners and by investing as partial or sole owners of projects including run-of-river hydro, biomass, geothermal and wind power. It prefers the investment approach because that method provides more control over projects. "We can assess project risks much more effectively as a shareholder. If we're just a buyer, we cannot really monitor and control the project."

67. None of the three independent wind-power developers contacted engage in build-operate-transfer (BOT) deals in developing countries. One of those that is active in China said that it had considered a consulting business and a BOT strategy initially but ascertained that the business culture in China and the expectations of provisional governments necessitated investment.

68. The three informants reported using a mix of their own staff, their local partners' staff, local vendors and international vendors to perform the professional services required at each step in developing a wind-power project. Table 2 shows a matrix of how and where these developers procure services. Developers reported that the timelines from site identification to commercial operation date vary from one-and-half years to four years.

69. The trade in services associated with wind-power development can create synergistic benefits that help to accelerate the deployment of wind power in countries with little or no history of wind-power development. It also provides tangible economic benefits to local communities apart from the provision of

electricity. The wind-power developer active in South Asia and South America estimated that 30% of the cost of a typical wind-power installation is spent paying local vendors.

70. Additionally, operations and maintenance for the lifespan of the wind farms is transferred to local firms soon after commercial operations begin. This same developer reported that, during the WTG warranty period, local operation and maintenance contractors are trained by the WTG manufacturer. "As soon as the warranties are up, we get out of our O&M agreement with the expensive North American and European suppliers and turn to local support for that."

China becoming world's leading user and producer of wind power technology

71. China more than doubled its wind-power capacity in 2008, installing 6,300 MW to reach 12,210 total installed capacity (GWEC 2009). China has adopted an official national wind-power target of 30,000 MW by 2020, but experts on the Chinese wind-power market report that the country is already exceeding its incremental goals, and that unofficial statements predict an upward revision of the 2020 target to 100 000 MW of wind power.

72. The growth of China's wind-power sector has been driven by incentives for wind-power developers and policies that encouraged foreign investment. Similar policies also facilitated rapid growth of the country's wind-turbine generator (WTG) manufacturing capacity, and today China is poised to soon become an international powerhouse for WTG and component manufacturing.

73. China's domestic market in 2008 was "a key new growth frontier" for Chinese WTG manufacturers as well as for European manufacturers Nordex, Vestas and Gamesa, and the American manufacturer GE Energy. All of these firms and others have invested in Chinese-based production facilities (EER, 2009).

74. According to one wind-power developer active in China, the number of domestically owned WTG manufacturers there has grown from just one in 2004—Goldwind—to approximately 60 in 2009. EER lists Goldwind as the leading Chinese WTG manufacturer in 2008, followed by Sinovel, Dongfang and Windey (EER, 2009).

75. With lower fixed and operating costs than manufacturers in OECD countries, China's domestic manufacturing capacity will enable the country to continue its robust internal growth of installed capacity. China is also expected to soon emerge as a major exporter, according to multiple industry sources. "Once they've met domestic demand, they will start to export and that will put a lot of pressure on the international players," said one. "Certainly there are questions about the quality and reliability [of Chinese manufacturers]. They're not at the international standard yet, but they will get there."

76. China has charted this course for growth with effective policies. In 2003, China liberalized its electricity market, separating generation from distribution and creating multiple enterprises. All entities remained state-owned, but the legislation guaranteed IPPs "free and equal access to the grid" in principle. Since 2004, Chinese-foreign joint ventures in wind-power development have been encouraged with favourable tax policies. Tax policies have also favoured Chinese WTG manufacturers that partner with foreign manufacturers and technology companies. And the renewable energy law enacted in 2006 requires that grid operators provide interconnection for renewable-power generators.

77. According to one wind-power developer, due to low rates of return on investment, IP risk and other risk factors like regulatory uncertainty, some major energy companies from OECD countries have pulled out of China's wind-power development market. But for one of the developers interviewed, the magnitude of the opportunities in China merit continued involvement. "It's going to be the world's biggest wind-power market."

78. One advantage that China offers to developers from OECD countries is that environmental analyses and administrative approvals are processed more rapidly than in OECD countries. One developer estimated that a typical development timeline from site identification to plant start-up in China is 18 months, while in his home country it typically takes at least three years. Additionally, turbines can be acquired more quickly from domestic producers than from the large European, American and Japanese WTG manufacturers—who until the end of 2008 were backlogged with orders.

79. Chinese subsidies for wind power have evolved significantly from an initial programme that compensated generators for their costs plus a regulated rate of return. According to two companies active in China, today's support system for wind power includes both concession projects, for which low bidders usually secure contracts, and preferential FITs established on a province-to-province basis by the National Development and Reform Commission (NDRC). These sources report that the current pipeline of wind-power projects consists of 30% concession-based contracts and 70% FIT regimes, but that the balance is shifting toward the concession approach, which will soon constitute 80% to 90% of the pipeline of new projects. Current FITs range from CNY 500 to CNY 760 per MWh.

80. China has offered incentives such as access to industrial sites at subsidized rents to Chinese firms that partner with foreign WTG technology licensors, according to informants. "This has been very important to [our Chinese partners]," said one informant from a European WTG technology firm that has licensed its technology to and invested in Chinese WTG manufacturers.

81. Leading WTG manufacturers have been investing in Chinese production facilities for more than 10 years. In 1998, Nordex (Germany) established a joint venture with Xi'an Aero Engine to assemble 600-kW turbines. In 2006 and 2007, it established a rotor blade plant for its 1.5 MW turbines, partnering with Ningxia Electric Power Group and the Ningxia Tianjing Electric Energy Development Corp. (*Climate Change Business Journal*, 2008).

82. In 2005, China enacted a 70% local-content requirement for wind-power projects. In the opinion of two of the companies contacted for this study, this has not been a problem for foreign WTG manufacturers because they were already sourcing, or planning to source, materials and components from Chinese suppliers. "We are meeting the 70% local-content requirement in China through a wide range of cooperation with Chinese sub-suppliers," said a representative for a WTG manufacturer operating in China.

83. This should not imply that doing business in China is easy. One European source for this study reported that his firm's executives spent many years cultivating relationships and performing small contracts in China before it established what would become its core business relationships with firms to which it licensed technology and in which it invested. The Chinese cultural emphasis on personal relationships necessitated such a long period of networking and courtship, according to the individual. "It is very important to them that they have personal knowledge of and trust in key persons in the firm. We built that up over some time." (He said that personal relationships have similar importance in business culture in India.)

84. Firms operating in China reported that IP risk is real. Three interviewees said IP theft in the WTG manufacturing sector has occurred there, including one case in which WTG blades almost identical to an overseas company's designs are being sold in China. But their firms only deal with Chinese companies that have a large international presence, including those listed on the U.S. NASDAQ stock exchange. Hence, their IP is secure because their Chinese counterparties are heavily dependent on maintaining their reputations for integrity.

85. Supportive policies for foreign-Chinese joint ventures in wind farms have been adjusted recently to provide comparable and even favourable treatment to wholly owned Chinese firms, according to a wind-power developer active in China. This individual reported that when it entered the Chinese market in 2004, its Chinese joint ventures received lower tax rates and exemptions from value-added taxes on equipment. Today these advantages have been eliminated or offered at parity to wholly owned Chinese ventures. Additionally, the government has capped the debt levels for wind-power projects developed by Chinese-foreign joint ventures at two-thirds, while wholly owned Chinese developers can leverage up to 80% of project finance. "For a typical $100 million project, this means the equity that has to go in is $33 million for the foreign JV and only $20 million for the wholly owned Chinese firm," said one developer.

86. This source observed that China's renewable-energy policies since 2003 have been very good for China. First the government created incentives for foreign investment and technology transfer, then as its domestic capacity grew, it restored the balance and even began favouring domestic firms with policies such as the debt limits for foreign joint ventures. "What was previously a playing field tilted toward foreign investors now tilts well the other way now."

87. Similarly, the representative of a WTG manufacturer operating in China reported that there seems to have been a shift in policies and incentives to increasingly favour domestic WTG manufacturers over foreign. This source said that a particular challenge of doing business in China is that laws and regulations tend to leave a lot of room for interpretation in enforcement. "You only find out the implications after you've already begun to operate. You learn about them in dialogue with Chinese associates and in day-to-day business. There is a kind of insecurity that regulators may use their discretion to favour domestic suppliers. Because regulations are written in a general way, this kind of treatment can be very difficult to document."

88. At the same time, he reported that his firm is optimistic about its future in China because Chinese authorities remain highly motivated to build their wind-power capacity and WTG manufacturing sector. "The challenge for foreign-owned enterprises is to find out how you can add value to developing the Chinese wind-energy sector."

Conclusions

89. Wind Power is a global industry that achieved revenues of more than $55 billion in 2008. The industry is heavily engaged in trade primarily in goods but also in services, with international supply chains and extensive trade in finished WTGs. The industry's rapid growth over the last 12 years has been facilitated by an increasingly diverse array of cross-border investments, partnerships, joint ventures and alliances (*Climate Change Business Journal*, 2008).

90. The enormous growth of wind power generating capacity since 1996 has been concentrated in Europe, North America and a handful of Asian nations. Most developing nations still deploy no utility-scale wind power, and growth has slowed or stopped in recent years in several developing nations that had achieved some wind power deployment earlier. Growth both in percentage terms and in net annual capacity added have declined in mature European markets such as Germany and Spain. In order for wind power to achieve its potential contribution to GHG mitigation by 2030, viable markets must emerge in many more developing nations.

91. China's emergence as one of the largest users and producers of wind power technology has been facilitated by an effective policy mix including liberalized electricity markets, incentives for wind-power generators, and incentives for foreign investment in both WTG technology and wind-power finance and development. China's extraordinary success in wind power is also likely due to inherent characteristics—such as China's fast GDP growth, its financial capabilities, its manufacturing expertise and capacity,

entrepreneurial spirit and low labor costs. However China's renewable energy policies should be examined with a view toward gleaning lessons applicable to other developing countries.

92. The Clean Development Mechanism has been an invaluable financing tool for wind power and other renewable energy technologies in developing countries that would otherwise lack the financial capacity to support the high upfront investment costs of renewable energy technologies. Providing additional resources to increase the capacity of the CDM executive board and staff and the efficiency of the registration process could have significant benefits for increased renewable energy deployment in developing nations.

93. Integration and harmonization of EU renewable energy support programs could result in more economically efficient deployment of wind and other renewable energy resources based on resource location rather than national borders. There are major stakeholder concerns about such a shift. More study is required to quantify the risks and benefits and to ascertain how such a transition would be combined with the larger policies around integration of European energy markets.

94. The key factors in a developing nations' deployment of wind power and other renewable energy technologies include its energy policies, the structure and pricing of its electricity markets, its financial capacity to subsidize the high up-front investment costs of renewable energy and other domestic policies and market factors. Discussions in multilateral trade and climate change fora should focus on how to effectively assist developing nations in creating the economic, policy and market conditions needed to support more deployment of wind power and other renewable energy technology.

95. The global transition from the current carbon-intensive electricity generation base to the low-carbon power capacity that must accompany GHG mitigation and atmospheric stabilization will be extraordinarily complex and expensive. Much additional research is needed to inform and develop strategies that will enable developing countries in particular to generate increasing proportions of their electricity from low-carbon renewable power sources.

96. With its limited number of sources, this paper paints with a broad brush, and perhaps its major contribution is to highlight topics for further research. Suggested research topics include: What mix of policy tools can most effectively and feasibly support deployment of wind and other renewable energy technology in developing nations? What can developed countries and multilateral agencies do to effectively support the adoption and enforcement of such policy measures in developing countries? Where and to what extent is inadequate transmission capacity a primary barrier to renewable energy deployment in developing countries? What financing strategies can be brought to bear to support the building of additional transmission capacity to connect regions rich in wind, solar, biomass and geothermal resources with areas of high electricity demand? Where do tariffs and non-tariff barriers significantly raise the cost of importing renewable energy technology and how can those tariffs and trade barriers be reduced or eliminated? What, if any, policies and incentives can be introduced to speed the wind power technology innovation needed to make economic use of onshore wind power sites with low average wind speeds?

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