Annex 14

INITIAL BACKGROUND DOCUMENT ON THE DEVELOPMENT OF WIND POWER GLOBALLY

I. Background

1. At its forty-ninth meeting the CDM Executive Board requested the secretariat, based on inputs from an independent consultant, to prepare a background document on the development of wind power globally, in particular in developing countries. The Board further requested that this document should include information on the historical trends related to investment and operating costs and policy supports, including inter alia feed-in tariffs and renewable portfolio standards.

2. This initial background document has been prepared by the secretariat on the basis of published data and experts' analysis and further consultations with relevant international agencies, including the International Energy Agency (IEA).

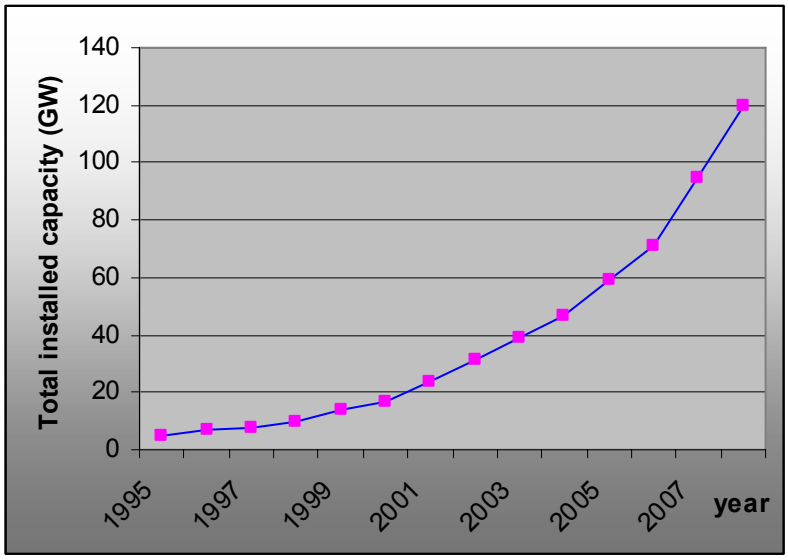
II. Statistics on the global development of wind power

3. The production of energy from renewable sources has increased significantly in recent years. The *Renewables Global Status Report 2009* (REN21 Secretariat[1]) indicates that total installed capacity of renewable energy, excluding large hydropower[2], was 280 gigawatts (GW) in 2008[3]. This represents a substantial increase on the installed capacity in 2004 of 160 GW. Interestingly it must also be noted that the installed capacity in developing countries in 2008 represented 43% of the global capacity. Furthermore the report highlights that in 2008 in both the United States and the European Union renewable energy accounted for 50% of the total new generation capacity added.

4. The *Renewables Global Status Report 2009* notes that wind power was the largest addition to global renewable energy sources in 2008 (excluding large hydropower). The total installed capacity as at the end of 2008 was 121 GW, which represents a significant overall increase from the 48 GW installed in 2004. Therefore the share of wind power in total renewable capacity, excluding large hydropower, has increased from 30% in 2004 to 43% in 2008.

[1] http://www.ren21.net/globalstatusreport/g2009.asp
[2] REN@! Degines large hydropower as plants with a capacity greater than 10MW
[3] Including large hydropower, global renewable power capacity reached an estimated 1,140 GW in 2008

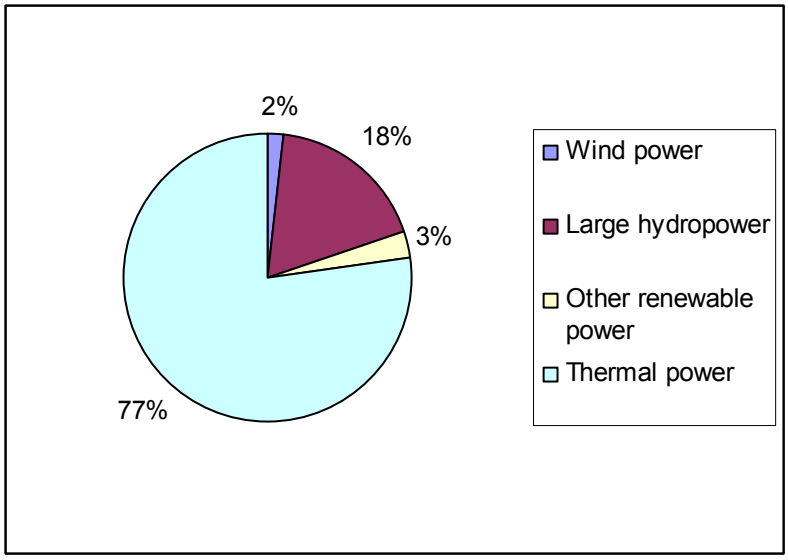
Figure 1: Trends in installed wind power in the world



*Source: Renewables Global Status Report 2009 (*http://www.ren21.net/globalstatusreport/g2009.asp*)*

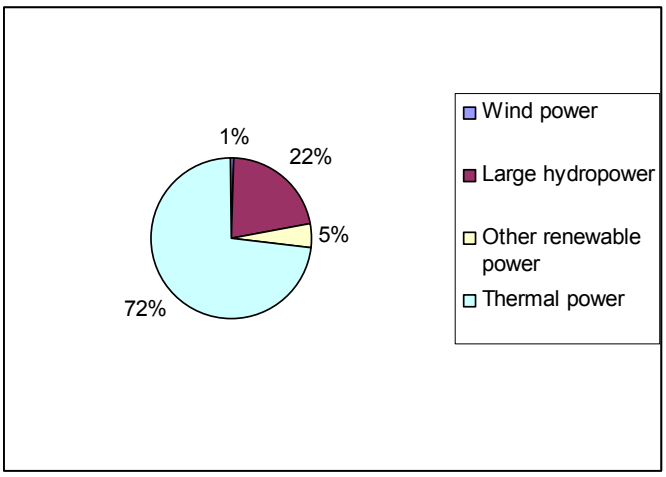
5. Thermal power constituted 77% of the 4,3003 GW total global installed electrical capacity globally in 2006. Wind power only contributed 2% of this installed capacity (see Figure 2 below). The share of thermal power in developing countries was slightly less (see Figure 3 below) at 72%. However wind accounted for just 1% of installed capacity in developing countries.

Figure 2: Global electric power generation by source (2006)



*Source: Renewables Global Status Report 2007 (*http://www.ren21.net/globalstatusreport/g2007.asp*)*

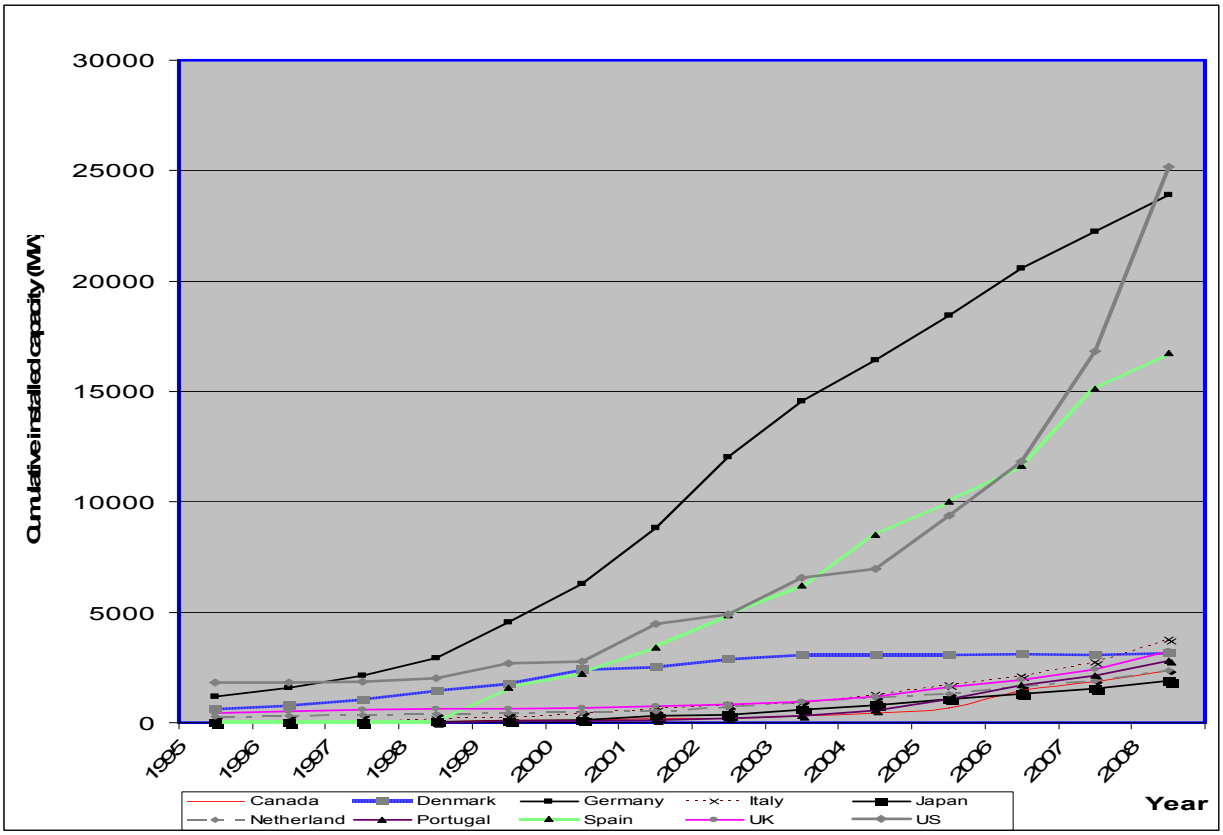
Figure 3: Electric power generation by source in developing countries (2006)



Source: Renewables Global Status Report 2007 (http://www.ren21.net/globalstatusreport/g2007.asp)

6. While over 80 countries around the world had commercial wind power installations by 2008, (including recent additions in Mongolia and Pakistan and projects were under development in countries sub-Saharan African including Ethiopia, Kenya, and Tanzania.), the total installed capacity globally and the rate of new installation is dominated by a relatively small number of countries. In 2008 the United States added 8.4 GW of new capacity to overtake Germany as the world leader in terms of installed capacity. China, India and Germany between them also accounted for over 10 GW of the total installed capacity in 2008. Figure 4 below presents that trends in total installed capacity in major developed economies. The leading contribution of Germany, the United States and Spain is evident from the graph.

Figure 4: Trends in installed wind power in major developed countries

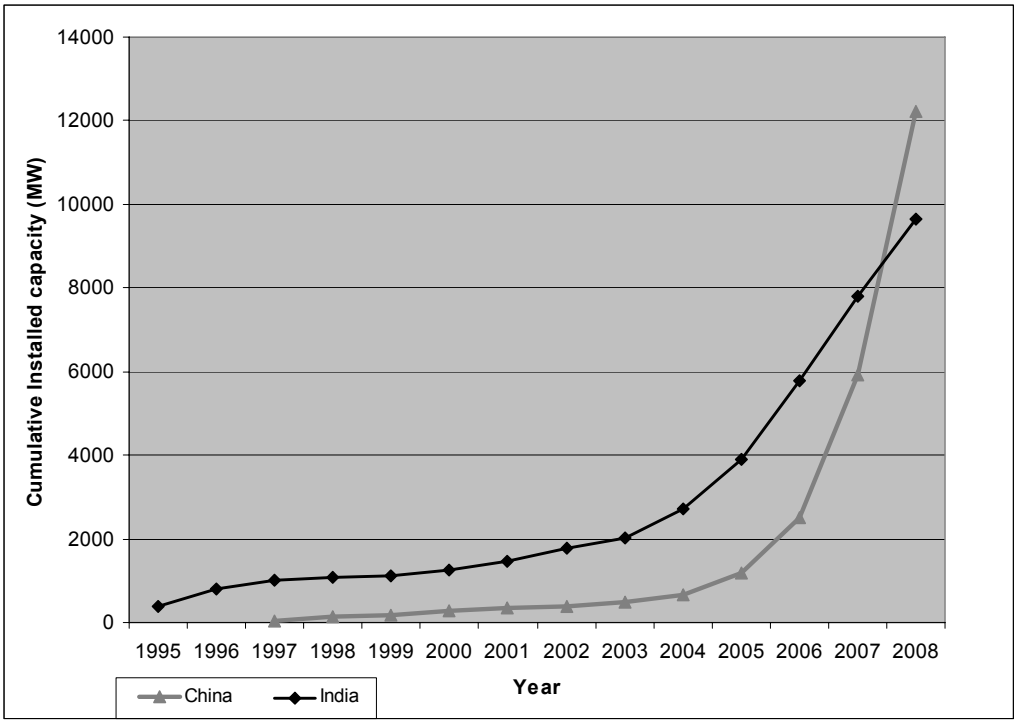


Source: *Reproduced using the charts available at IEA Wind Energy Annual Report 200[4], and current market and future perspective for wind energy in Germany[5].*

7. In 2008 China overtook India as the fourth largest wind power developer in the world (see Figure 5 below). Wind power in other developing countries such as Argentina, Bangladesh, Brazil, Caribbean States, Chile, Colombia, Cost Rica, Egypt, Ethiopia, Jordan, Indonesia, Mexico, Morocco, Namibia, Nicaragua, Pakistan, Philippines, South Africa, Tunisia, Viet Nam have not been included in the chart as total installed capacity of each country are not significant compared with these two major developing countries.

[4] http://www.ieawind.org/AnnualReports_PDF/2008.html
[5] http://www.wind-energie.de/en/wind-energy-in-germany

Figure 5: Trends in installed wind power in the major developing countries.



Source: Reproduced using the charts available at Background Paper on Chinese renewables status report October 2009[6], and Wind power development in India (Mahesh Vipradas, Senergy Global Ltd.).

III. Trends in investment and operating costs

Overview of relevant costs

8. In common with most projects the investment and operating costs of wind power projects vary from country to country and also within countries. The factors impacting the variability of costs for wind power project include, *inter alia*:

(a) The country's availability of wind resources;

(b) Type of project (i.e. whether located onshore or offshore);

(c) Type and size of the turbines used; and

(d) Maturity of the industry and local market conditions.

9. These factors need to be taken into account under a qualitative approach when comparing the general trends for investment and operating costs. This is particularly important in comparing data between developed and developing economies.

10. The maturity of the market also has significant impacts on the availability of data. Therefore the availability of data is significantly higher for countries where this industry has already matured in recent years, such as USA, Germany, Spain or Denmark. Apart from India and China, for most developing

[6] http://www.ren21.net/pdf/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf

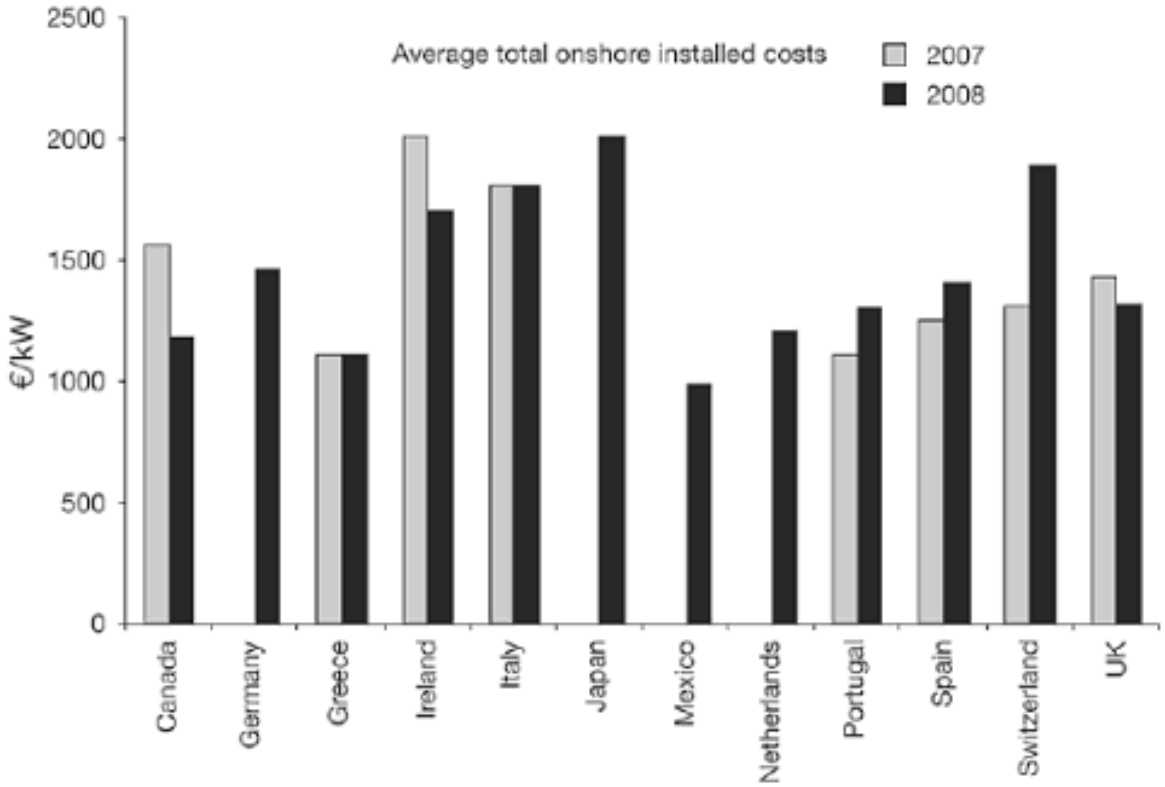
countries the availability of information is limited due to the fact in most countries the market for wind power remains in an embryonic stage.

Turbine and total installed project costs

11. The International Energy Agency (IEA) collects data[7] from its members states[8] via a Wind Agreement[9]. Several member countries reported stable or slightly increasing wind turbine costs from 2007 to 2008 (Figure 6 below). Turbine costs reported by the IEA member countries averaged from a low of 977 €/kW (USA) to a high of 1,800 €/kW (Austria) for 2008. Total installed costs onshore for 2008 in the reporting countries ranged from a low of 984 €/kW (Mexico) to a high of 1,885 €/kW (Switzerland). Total installed costs offshore ranged from 2,100 €/kW (UK) to 3,230 €/ kW (Germany).

12. It should be noted, however that wind turbines are generally not priced per MW but by swept rotor area, since the annual energy production at any given location is largely proportional to the swept rotor area, whereas the production varies only marginally with the size of the generator of the turbine.[10]

Figure 6: Average installed costs[11] of wind projects 2007-2008



Source: *IEA Wind Energy Global Report 2008*

[7] "IEA Wind Energy Global Report 2008" (http://www.ieawind.org/AnnualReports_PDF/2008.html)
[8] Australia, Austria, Canada, Denmark, Finland, Germany, Greece, Ireland, Italy, Japan, Republic of Korea, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States
[9] http://www.ieawind.org/about_co-operative_agree.html
[10] World Bank, "REToolkit: A Resource for Renewable Energy Development, June 2008"
[11] Costs included: turbines, roads, electrical equipment, installation, development and grid connection

13. The breakdown of the total installed costs among the IEA member countries is not available for all member countries. However some have reported how costs of wind projects are distributed. Table 1 below provides further details

Table 1: Estimated Average Turbine Cost and Total Cost for 2008 in IEA Wind member countries

Country	Turbine cost (€/kW)	% (Turbine cost/Total installed cost)	Total installed cost (€/kW)
Germany	941 - 1,340	74.7 - 80.8%	1,260 - 1,659
Ireland	1,100	65%	1,700
Italy	1,270	70.6%	1,800
Japan	1,000 - 1,200	55.6 - 54.5%	1,800 - 2,200
Portugal	1,061	81.8%	1,297
Switzerland	1,450	76.9%	1,885

Source: *Derived from IEA Wind Energy Global Report 2008*

14. The average installed plant in Italy can be used as a more specific example. The cost of a medium-sized wind farm (30 MW) in this country, at a site of medium complexity, with 15 km of paths/roads and 12 km of electric line for connection to the high-voltage grid, is approximately 1,800 €/kW. The annual cost of operation and maintenance has been estimated to be about 54 €/kW (i.e. 3% of total cost), which includes leasing of the terrain, insurance, and guarantees. This total cost is subdivided as follows:

- Turbines, installation, and commissioning, 1,270 €/kW: 70.6%
- Development, namely site qualification, design, administrative procedures, and so on, 236 €/kW: 13.1%
- Interest on loans, 196 €/kW: 10.9%
- Connection to the grid, 73.8 €/kW: 4.1%
- Civil engineering work, 23.4 €/kW: 1.3%

15. In general, the experience gained in the development of the wind power sector in many different countries indicates a decreasing trend for the total investment costs (capital costs) required by project developers. Recent data for developed countries (IEA Wind Energy Global Report 2008 and EPRI) however has indicated that the trend of decreasing investment costs has slowed over time and in some situations in recent years the investment costs have begun to increase once more.

16. From an analysis of over 130 proposed CDM project submitted for registration in China the secretariat has also noted that:

- The specific investment cost per capacity installed indicates a slight decreasing trend, from 9.6 mRMB/MW for projects with a start date in 2006 to 9.4 mRMB/MW for projects with a start date in 2007 and/or 2008;

- Specific investment cost per unit of electricity generated indicates a slight increasing trend, from 4,330 RMB/MWh for projects with a start date in 2006 to 4,303 RMB/MWh for projects with a start date in 2007 and/or 2008;

Operation and maintenance costs

17. According to IEA Wind data[12], general costs for service, consumables, repair, insurance, administration, lease of site, and so on, for new large turbines ranged from 1.3% to 1.5% of capital cost per year. When O&M costs are indeed mentioned by the member countries, they are reported as fairly constant over the years.

18. The World Bank[13] notes that the O&M costs for wind power generation typically run about 1.5-2 US cents/kWh. The note also indicates that the cost of electricity from modern grid-connected wind farms ranges from 7-12 US cents/kWh depending on the site and the strength of the wind resource and that the "*wind farms generally must compete against conventional grid power options, which vary widely depending on whether diesel, gas, coal or other primary energy sources are the alternative. Wind power will generally replace generation from the more expensive marginal medium load generating units on the grid*."

19. From an analysis of over 130 proposed CDM project submitted for registration in China the secretariat has also noted that:

- The O&M costs level indicates an increase from 94.4 RMB/MWh for projects with a start date in 2006 to 100.9 RMB/MWh for projects with a start date in 2007 and/or 2008 (i.e. 6.9% increase);
- The O&M cost ratio (*vs* "Total investment") indicates a slight increase from 2.26 for projects with a start date in 2006 to 2.37 projects with a start date in 2007 and/or 2008 (i.e. 4.9% increase);

IV. Use of policy supports

Policy targets

20. The *Renewable 2007 Global Status Report* indicates that 64 individual countries have instituted targets for renewable energy. The legal nature and definition of these targets differ from country to country. In certain cases the target is specified as a quantity of expected installed capacity, in others as a percentage of final consumption or total primary energy requirement. These countries include all EU member states and 23 developing countries. Neither the United States nor Canada have adopted national targets, however 29 US States and the District of Columbia, and 9 Canadian provinces have adopted renewable energy targets. Such sub-national targets have also been adopted in other regions including India.

21. The following 22 developing countries have adopted national targets: Algeria, Argentina, Brazil, China, the Dominican Republic, Egypt, India, Indonesia, Iran, Jordan, Malaysia, Mali, Morocco, Nigeria, Pakistan, the Philippines, Senegal, South Africa, Syria, Thailand, Tunisia, and Uganda.

22. As with developed countries the nature and scope of these targets differ. Some notable examples discussed in REN21 include:

(a) China: Long-term renewables development plan, issued in September 2007, which contains a national target of 15 percent of primary energy by 2020 (individual technology targets are also included, such as 300 GW of hydro, 30 GW of wind, 30 GW of biomass, and 1.8 GW of solar PV);

[12] "IEA Wind Energy Global Report 2008" (http://www.ieawind.org/AnnualReports_PDF/2008.html)
[13] World Bank, "REToolkit: A Resource for Renewable Energy Development, June 2008", based on REN 21's Global Status Report for 2007

(b) Argentina: Target of 8 percent of electricity from renewables by 2016 (excluding large hydro).

(c) Egypt revised its target to 20 percent share of electricity by 2020, up from the previous target of 14 percent (which included 7 percent from hydro). This new target entails more than 12 percent for wind power, which is expected to reach 8 GW by 2020.

(d) Uganda enacted a comprehensive set of targets through 2017 in a new 2007 renewable energy strategy.

23. The establishment of renewable energy targets alone is not sufficient to deliver the desired outcome. Such aspirations must be underpinned by a policy support structure to ensure their effective delivery. There are three main categories of policies whose specific goal is to promote renewable energy: (a) price-setting and quantity-forcing policies (mandate prices or quantities); (b) investment cost reduction policies (provide incentives in the form of lower investment costs); and (c) public investments and market facilitation activities (offer a wide range of public policies that reduce market barriers and facilitate or accelerate renewable energy markets). Historically, governments have enacted these policies in a rather ad-hoc manner .

24. In recent years, a combination of these three main categories have been applied in many countries to promote renewable energy (e.g. targets set on a national level that may specify total primary energy from renewables and/or minimum renewable energy shares of electricity generation). To cite a few examples: the European Union's target of 22% of total electricity generation from renewables by 2010, with individual targets set for each individual member state; Japan's target of 3% of total primary energy by 2010; and India's goal to achieve 10% of power generation's annual additions from renewable sources by 2012 . The regulatory framework of such targets/goals for renewable energy is as important as the subsidies themselves.

Policy support programmes

25. Two main types of regulatory policies have been used to open the grid to renewables, namely: (a) "pricing" system; and (b) "quota" system (RPS – Renewable Portfolio Standard). The former guarantees price, while the latter ensures market share through government mandated targets or quotas. They are usually referred to as "feed-in-tariff" and "mandated targets" or "RPS" respectively.

26. A feed-in system provides renewable energy producers are provided with at fixed, minimum prices, which are generally set at a higher level than the regular market price. In addition, the payments are usually guaranteed over a specified period of time or until a certain level of operational hours have been reached . Tariffs may have a direct relationship with cost or price, or may be chosen in a more deliberate way, to spur investment in renewables. Such tariffs usually also require regulations in relation to grid access for renewable power generation sources.

27. By means of RPS the government sets a target, allowing the market to determine the price. Typically, governments mandate a minimum share of capacity or generation of electricity (generally grid-connected only), or a share of fuel, to come from renewable sources. The mandate can be placed on producers, distributors or consumers.

28. The sources and data assessed when compiling this report indicate that, up to date, the feed-in systems have been responsible for most of the additions in renewable electricity capacity and generation, where it could be seen in many cases a decrease in trends of costs through technology advancement and economies of scale, in addition to the development of a national industry. The results from the quota systems tend to be more uneven over time.

Table 2: Cumulative Number of Countries/States/Provinces Enacting RPS and Feed-In Policies

Year	Feed-In Policies		RPS Policies	
	Cum #	Countries/States/Provinces added that year	Cum #	Countries/States/Provinces added that year
1978	1	United States	0	--
1983	1	--	1	Iowa (USA)
1990	2	Germany	1	--
1991	3	Switzerland	1	--
1992	4	Italy	1	--
1993	6	Denmark, India	1	--
1994	8	Spain, Greece	2	Minnesota (USA)
1996	8	--	3	Arizona (USA)
1997	9	Sri Lanka	6	Maine, Massachusetts, Nevada (USA)
1998	10	Sweden	9	Connecticut, Pennsylvania, Wisconsin (USA)
1999	13	Portugal, Norway, Slovenia	12	New Jersey, Texas (USA); Italy
2000	13	--	13	New Mexico (USA)
2001	15	France, Latvia	15	Flanders (Belgium); Australia
2002	21	Algeria, Austria, Brazil, Czech Republic, Indonesia, Lithuania	18	California (USA); Wallonia (Belgium); United Kingdom
2003	28	Cyprus, Estonia, Hungary, South Korea, Slovak Republic, Maharashtra (India)	19	Japan; Sweden; Maharashtra (India)
2004	33	Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India)	34	Colorado, Hawaii, Maryland, New York, Rhode Island (USA); Nova Scotia, Ontario, Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, Orissa (India); Poland
2005	40	Karnataka, Uttaranchal, and Uttar Pradesh (India); China, Turkey, Ecuador, Ireland	38	District of Columbia, Delaware, Montana (USA); Gujarat (India)
2006	43	Ontario (Canada), Argentina, Thailand	39	Washington State (USA)
2007	49	South Australia (Australia), Albania, Bulgaria, Croatia, Macedonia, Uganda	44	Illinois, New Hampshire, North Carolina, Oregon (USA); China
2008	61	Queensland (Australia); California (USA); Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu and West Bengal (India); Kenya, the Philippines, Poland, Ukraine	49	Michigan, Missouri, Ohio (USA); Chile; India
2009 (early)	63	Australian Capital Territory (Australia); South Africa	49	--

Source: *Renewables Global Status Report 2009 (http://www.ren21.net/globalstatusreport/g2009.asp)*

Comparison of policy support programmes

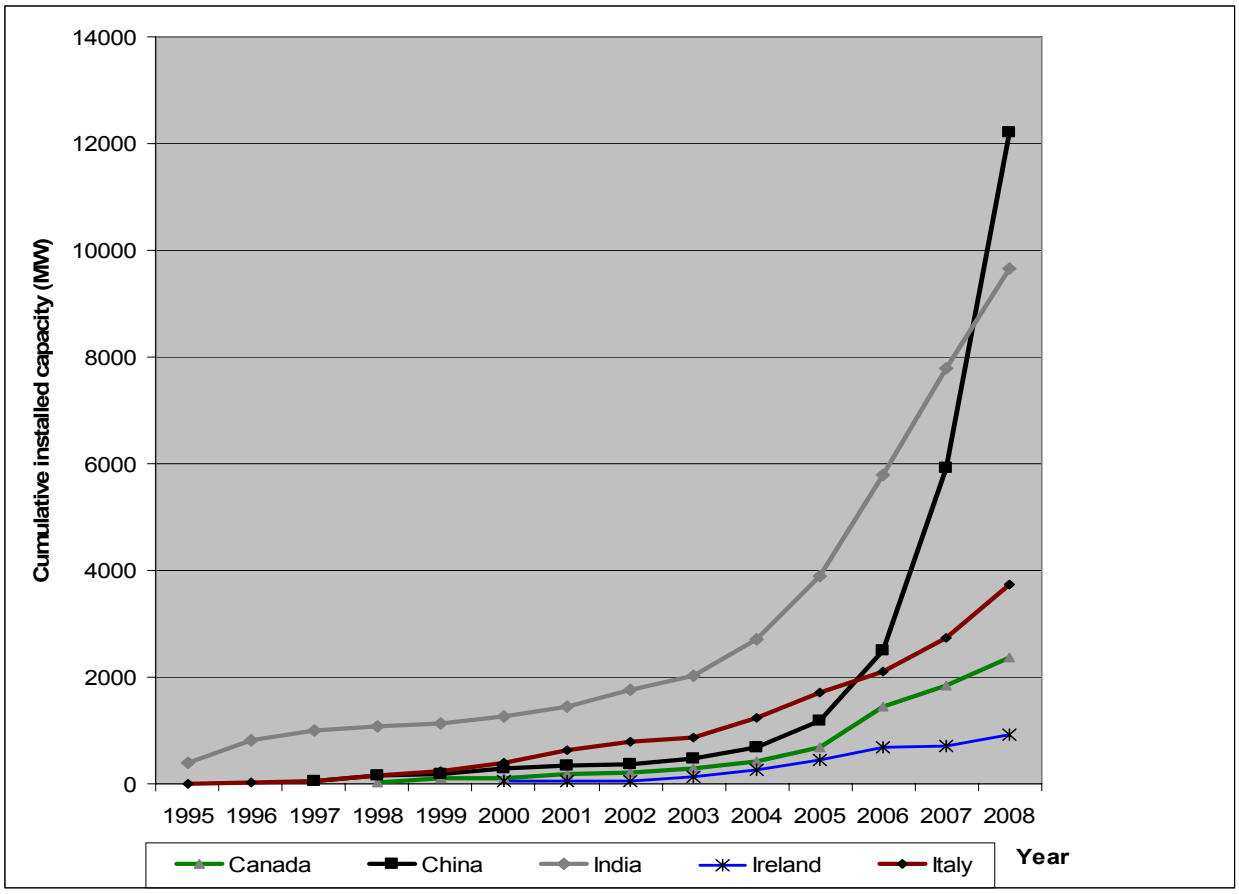
29. The advantages and disadvantages of pricing systems and quota systems have been well summarized in by the Secretariat of the International Conference for Renewable Energy 2004. Table 3 below provides an overview of this discussion. It should be noted however that, in common with any policy intervention, the success of the intervention will depend not on the theory followed but more importantly on the precision in its implementation.

Table 3: Advantages and disadvantages of pricing and quota systems

Pricing systems	
Advantages	**Disadvantages**
Flexible – can be designed to account for changes in technology and the marketplace	If tariffs are not adjusted over time, consumers may pay unnecessarily high prices for renewable power
Encourage steady growth of small- and medium-scale producers	Can involve restraints on renewable energy trade due to domestic production requirements.
Low transaction costs	
Ease of financing	
Quota systems	
Advantages	**Disadvantages**
Promote least-cost projects - cheapest resources used first, which brings down costs early on	High risks and low rewards for equipment industry and project developers, which slows innovation
Provide certainty regarding future market share for renewables	Price fluctuation in "thin" markets, creating instability and gaming
Perceived as being more compatible with open or traditional power markets	High transaction costs
	Lack flexibility—difficult to fine-tune or adjust in short-term if situations change.

30. The success of feed-in-tariffs in the deployment of wind power is further demonstrated by Figure 7 below showing the trends in selected countries which have switched the focus of their policy supports to a feed-in-tariff in recent years.

Figure 7: Trends in installed wind power in the countries which implemented FiT (2004- 2006)



Source: *This chart was reproduced using the charts available at IEA Wind Energy Annual Report 2008, current market and future perspective for wind energy in Germany,, Background Paper on Chinese renewables status report in October 2009 (, and Wind power development in India.*

V. Conclusion

31. The Board may wish to discuss the implications of this report for its policy discussion, noting the general cost of wind power, the rapid development of installed capacity in wind power and the varied network of policy supports used the achieve this growth.

32. The Board may wish to mandate further work in this area if more detailed analysis is required.

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