1.0 Introduction
At the close of 2013, wind generation was meeting nearly 4% of the world's electricity demand (WWEA 2014) with approximately 318.1 GW of wind power operating in 103 countries (GWEC 2014). Nearly 85% of the world's wind generating capacity resides in the 21 countries participating in the International Energy Agency (IEA) Wind Implementing Agreement (IEA Wind), an international co-operation that shares information and research activities to advance wind energy deployment. These IEA Wind member countries added nearly 30 GW of capacity in 2013, which is almost 83% of the worldwide market for the year. With approximately 270 GW of wind generating capacity, electrical production from wind met 3.86% of the total electrical demand in the IEA Wind member countries (Tables 1–4).

This IEA Wind 2013 Annual Report contains chapters from each member country and from the Chinese Wind Energy Association (reporting on the People’s Republic of China) and the European Wind Energy Association (EWEA) and European Commission reporting on activity in European Union (EU) countries. The countries report how much wind energy they have deployed, how they benefit from wind energy, and how their policies and research programs will increase wind power's contribution to the world energy supply. This annual report also presents the latest research results and plans of the 13 IEA Wind active co-operative research activities (tasks) that address specific issues related to wind energy development.

This Executive Summary presents highlights and trends from the chapters about each member country and research task, as well as compiled statistics for all countries. Data from the past 16 years, as reported in

<table>
<thead>
<tr>
<th>Table 1. Key Statistics of IEA Wind Member Countries 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total installed capacity</td>
</tr>
<tr>
<td>Total offshore wind capacity*</td>
</tr>
<tr>
<td>Total (net) new wind capacity installed 2013</td>
</tr>
<tr>
<td>On land 27.20 GW</td>
</tr>
<tr>
<td>Total annual output from wind</td>
</tr>
<tr>
<td>Wind generation as a percent of IEA Wind members' national electric demand</td>
</tr>
</tbody>
</table>

* In the International Electrotechnical Commission (IEC) Standard Document, IEC 61400-3 (Offshore Wind Turbines), offshore wind turbine is defined as a “wind turbine with a support structure which is subject to hydrodynamic loading.” For this report, wind turbines standing in lakes, rivers, and shallow and deep waters are considered offshore.
**Table 2. National Statistics of the IEA Wind Member Countries 2013**

<table>
<thead>
<tr>
<th>Country</th>
<th>Total installed wind capacity (MW)</th>
<th>Total offshore installed wind capacity* (MW)</th>
<th>Annual net increase in capacity (MW)</th>
<th>Total number of turbines</th>
<th>Average capacity of new turbines (kW)</th>
<th>Wind-generated electricity (TWh/yr)</th>
<th>National electricity demand (TWh/yr)</th>
<th>National electricity demand from wind** (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia***</td>
<td>3,239</td>
<td>0</td>
<td>655</td>
<td>1,651</td>
<td>---</td>
<td>9.2</td>
<td>226.0</td>
<td>4.1%</td>
</tr>
<tr>
<td>Austria</td>
<td>1,684</td>
<td>0</td>
<td>309</td>
<td>113</td>
<td>2,730</td>
<td>3.6</td>
<td>62.0</td>
<td>5.8%</td>
</tr>
<tr>
<td>Canada</td>
<td>7,803</td>
<td>0</td>
<td>1,599</td>
<td>4,377</td>
<td>2,000</td>
<td>17.5</td>
<td>560.0</td>
<td>3.1%</td>
</tr>
<tr>
<td>China</td>
<td>91,413</td>
<td>428</td>
<td>16,089</td>
<td>63,120</td>
<td>1,719</td>
<td>137.1</td>
<td>5,245.1</td>
<td>2.6%</td>
</tr>
<tr>
<td>Denmark</td>
<td>4,808</td>
<td>1,271</td>
<td>644</td>
<td>5,194</td>
<td>3,132</td>
<td>11.1</td>
<td>34.0</td>
<td>32.7%</td>
</tr>
<tr>
<td>Finland</td>
<td>448</td>
<td>26</td>
<td>190</td>
<td>210</td>
<td>3,200</td>
<td>0.8</td>
<td>83.9</td>
<td>0.9%</td>
</tr>
<tr>
<td>Germany</td>
<td>34,660</td>
<td>903</td>
<td>3,356</td>
<td>23,864</td>
<td>---</td>
<td>53.4</td>
<td>600.1</td>
<td>8.9%</td>
</tr>
<tr>
<td>Greece***</td>
<td>1,865</td>
<td>0</td>
<td>116</td>
<td>1,357</td>
<td>1,145</td>
<td>3.3</td>
<td>57.0</td>
<td>5.8%</td>
</tr>
<tr>
<td>Ireland</td>
<td>1,896</td>
<td>25</td>
<td>133</td>
<td>---</td>
<td>---</td>
<td>4.5</td>
<td>27.9</td>
<td>16.3%</td>
</tr>
<tr>
<td>Italy</td>
<td>8,554</td>
<td>0</td>
<td>434</td>
<td>6,391</td>
<td>2,014</td>
<td>14.9</td>
<td>317.1</td>
<td>4.7%</td>
</tr>
<tr>
<td>Japan</td>
<td>2,670</td>
<td>50</td>
<td>56</td>
<td>1,925</td>
<td>1,474</td>
<td>4.0</td>
<td>845.5</td>
<td>0.5%</td>
</tr>
<tr>
<td>Korea</td>
<td>561</td>
<td>2</td>
<td>74</td>
<td>326</td>
<td>1,721</td>
<td>0.9</td>
<td>532.2</td>
<td>0.2%</td>
</tr>
<tr>
<td>México</td>
<td>1,551</td>
<td>0</td>
<td>426</td>
<td>1,071</td>
<td>2,000</td>
<td>3.9</td>
<td>249.0</td>
<td>1.5%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,709</td>
<td>228</td>
<td>281</td>
<td>2,160</td>
<td>2,729</td>
<td>5.6</td>
<td>120.3</td>
<td>4.7%</td>
</tr>
<tr>
<td>Norway</td>
<td>811</td>
<td>2</td>
<td>98</td>
<td>356</td>
<td>2,500</td>
<td>1.9</td>
<td>129.2</td>
<td>1.5%</td>
</tr>
<tr>
<td>Portugal</td>
<td>4,709</td>
<td>2</td>
<td>192</td>
<td>2,739</td>
<td>2,000</td>
<td>11.9</td>
<td>50.6</td>
<td>23.5%</td>
</tr>
<tr>
<td>Spain</td>
<td>22,959</td>
<td>0</td>
<td>175</td>
<td>20,252</td>
<td>1,980</td>
<td>54.3</td>
<td>260.0</td>
<td>20.9%</td>
</tr>
<tr>
<td>Sweden</td>
<td>4,469</td>
<td>0</td>
<td>862</td>
<td>2,681</td>
<td>2,912</td>
<td>9.9</td>
<td>139.0</td>
<td>7.0%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>60</td>
<td>0</td>
<td>11</td>
<td>34</td>
<td>2,216</td>
<td>0.1</td>
<td>63.7</td>
<td>0.2%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10,861</td>
<td>3,653</td>
<td>2,422</td>
<td>5,413</td>
<td>---</td>
<td>26.1</td>
<td>375.9</td>
<td>6.0%</td>
</tr>
<tr>
<td>United States</td>
<td>61,110</td>
<td>6,590</td>
<td>29,209</td>
<td>189,278</td>
<td>167.7</td>
<td>4,058.2</td>
<td>14,036.7</td>
<td>3.86%***</td>
</tr>
</tbody>
</table>

* Bold italic indicates estimates
* A subset of total capacity
* * Total TWh from Wind/TWh total national electric demand x 100
* *** (GWEC 2014)
* **** Overall contribution to IEA Wind Member countries (total wind generated electricity/total electricity demand) x 100
previous IEA Wind documents (IEA Wind 1995–2012), are included as background for discussions of 2013 events.

### 2.0 National Objectives and Progress

IEA’s updated Technology Roadmap for Wind Energy (IEA 2013) now targets a goal of 15%–18% of global electricity coming from wind power by 2050. The previous target of 12% was seen as too conservative based on industry accomplishments to date and the need to reduce greenhouse gas (GHG) emissions. Significant investments will be required to reach the new goal. In 2013, wind energy supplied 4% of global electricity. IEA Wind member governments and industries establish national targets for renewable energy and wind energy (Table 4), design incentive programs (Table 11), and conduct focused research and development (R&D) programs to help reach these targets (Table 16). Their reasons for supporting wind energy include increasing employment and economic development, building a domestic industry, contributing to domestic energy supply, reducing GHG emissions and other pollutants, and replacing nuclear energy.

#### 2.1 National targets

Most IEA Wind member countries have targets for increasing the amount of renewable energy or low-carbon energy in the electrical generation mix. These targets are embedded in legislation, appear in roadmap documents, or have been announced by elected officials (Table 4). Some of these countries also have specific goals or targets for generation capacity of wind energy or wind energy contributions to electricity supply as part of their long-term energy strategies. National targets in several countries include separate goals for wind on land and offshore.

In response to European Union (EU) Directive 2009/28/EC, all EU member states have submitted National Renewable Energy Action Plans (NREAPs) detailing sectoral- and technology-specific targets and policy measures to reach the renewable energy systems target of 20% by 2020. As shown in Table 4, each country has goals adapted to its domestic situation.

Outside of Europe, planning is underway to increase wind power development. Canada set the goal to reduce GHG emissions by 17% below 2005 levels by 2020. The Chinese Plan of Action for Prevention and Control of Atmospheric Pollution proposed a 13% increase in non-fossil energy consumption by 2017. In Japan, a draft Basic Energy Plan published in 2013 and an industry roadmap confirm goals for renewable energy and identify issues to be solved. The Republic of Korea is shifting attention to wind and solar photovoltaics (PV) as alternatives to biomass as the main renewable resource. México is on track for wind generation to supply approximately 5% of electric consumption by 2024. In the United States, the President’s Climate Action Plan was released in 2013 to reduce greenhouse gas emissions and an update of the 2008 report, 20% Wind Energy by 2030, will be published in 2014 to describe progress and lay out a roadmap for an expanded U.S. Wind Vision.

#### 2.2 Progress

##### 2.2.1 Capacity increases

In 2013, IEA Wind member countries added 29.21 GW of net wind capacity, which is less than the 36.76 GW added in 2012 and the smallest capacity increase since 2009 (Table 5). As shown in Table 6, despite this overall decline in new deployments, nine countries increased capacity by more than 20% in 2013: Finland (67%), México (35%), United Kingdom (29%), Canada (26%), Australia (25%), Sweden (24%), Austria (22%), Switzerland (22%), and China (21%).

Eleven countries installed more capacity in 2013 than in 2012: Australia, Austria, Canada, Denmark, Finland, Germany, the Netherlands, Portugal, Sweden, Switzerland, and the United Kingdom. Five countries installed more than 1 GW: China (16.09 GW), Germany (3.36 GW), the United Kingdom (2.42 GW), Canada (1.60 GW), and the United States (1.09 GW) (Table 2), Australia, Denmark, Italy, México, and Sweden added more...
than 400 MW each. In all, 17 countries added more than 100 MW of new capacity. However, these additions to the total of new deployments in 2013 were more than offset by the dramatic decline in new installations in four countries: the United States, China, Spain, and Italy. Explanation for these declines can be found in the country chapters.

As a whole, capacity has increased in the IEA Wind member countries from less than 5 GW in 1995 to more than 268.8 GW in 2013 (Figure 1).

2.2.2 Electrical production

Although wind generation capacity only increased 12% in 2013, electrical production from wind increased 21%. These data suggest that new wind turbines are more productive per megawatt of rated capacity. Countries report that some of this increased productivity is due to better grid connection (reduced curtailment), as well as improved hardware and better wind plant siting and design.

Total wind energy electrical production from all IEA Wind member countries increased by 94.6 TWh in 2013. National electrical output from wind energy increased in all member countries except Japan. Meanwhile, total electrical demand from these countries increased by 339.2 TWh in 2013. Total electrical demand increased in Austria, China, Germany, Ireland, Korea, Portugal, Spain, Switzerland, the United Kingdom, and the United States; stayed the same in the Netherlands; and decreased in Canada, Denmark, Finland, Italy, Japan, Mexico, Norway, and Sweden.

Electrical production is influenced by the quality of the wind resource for the year, the operating availability of the wind plants, and the consistency of the transmission grid availability. Regarding the wind resource, correcting annual production to wind indexes is becoming more common as wind capacity increases and the effects of variations across years are experienced. These indexes are based on a long-term average wind resource, typically five to fifteen years. Table 7 compares the wind resource levels reported by some IEA Wind member countries in 2013.

The penetration level, or the percent contribution of wind generation to total electrical demand, increased in 2013 in all countries except the United Kingdom, Japan, and Korea, where it remained constant. Some countries set records in 2013 for wind penetration (Table 8). Denmark set the new world record by meeting nearly 33% of annual national electric demand from wind energy in 2013. Wind energy met nearly 27% of Spanish electricity demand in 2013 and was the largest single contributor to electricity generation for the entire year, surpassing nuclear, coal, and hydropower. Portugal met 23.5% of its 2013 electric demand from wind—on one day in December, instantaneous wind contribution to demand reached 90%, and 69% of the day’s consumption was supplied by wind energy. Table 9 shows wind penetration and national electrical demand for 2013.

2.2.3 Offshore wind progress and plans

Among the IEA Wind member countries, offshore wind systems totaling more than 6.59 GW were operating in 11 countries at the close of 2013 (Table 10). During 2013, more than 2.01 GW were added in the following countries: China (38 MW), Denmark (351 MW), Germany (623 MW), Japan (25

<table>
<thead>
<tr>
<th>Country</th>
<th>Renewable energy sources (RES) target</th>
<th>Wind energy target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4,400 MW increase from 2010–2020</td>
<td>2,000 MW increase from 2010–2020</td>
</tr>
<tr>
<td>Canada</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>China</td>
<td>15% of primary energy consumption from non-fossil energy by 2020</td>
<td>200 GW (30 GW offshore) by 2020</td>
</tr>
<tr>
<td>Denmark</td>
<td>100% by 2050; more than 35% renewable by 2020</td>
<td>50% by 2020</td>
</tr>
<tr>
<td>European Commission</td>
<td>20% by 2020</td>
<td>---</td>
</tr>
<tr>
<td>Finland</td>
<td>38% of gross energy consumption by 2020</td>
<td>6 TWh/yr (2.5 GW) in 2020</td>
</tr>
<tr>
<td>Germany</td>
<td>35% of electrical energy consumption by 2020</td>
<td>6.5 GW offshore by 2020 (formerly 10 GW offshore)</td>
</tr>
<tr>
<td>Greece</td>
<td>40% of electricity by 2020</td>
<td>---</td>
</tr>
<tr>
<td>Ireland</td>
<td>40% by 2020</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>17% by 2020</td>
<td>12 GW on land, 0.68 GW offshore by 2020</td>
</tr>
<tr>
<td>Japan</td>
<td>25% to 35% by 2030</td>
<td>5 GW by 2020</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>11% of consumption by 2035</td>
<td>18.2% of Renewable Energy by 2035</td>
</tr>
<tr>
<td>México</td>
<td>---</td>
<td>12 GW by 2020</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>14% by 2020; 16% by 2023; 20% reduction CO₂, in 2020 as compared to 1990 level</td>
<td>6,000 MW on land installed in 2020, 2050 MW offshore installed in 2020, 4,450 MW offshore installed in 2023</td>
</tr>
<tr>
<td>Norway</td>
<td>67.5% of total energy consumption by 2020</td>
<td>---</td>
</tr>
<tr>
<td>Portugal</td>
<td>31% of gross energy consumption by 2020</td>
<td>5,273 GW on land, 27 MW offshore by 2020</td>
</tr>
<tr>
<td>Spain</td>
<td>20% of overall energy consumption by 2020</td>
<td>35 GW on land, 0.75 GW offshore by 2020</td>
</tr>
<tr>
<td>Sweden</td>
<td>50% of overall energy consumption by 2020, 30 TWh by 2020: 20 TWh on land, 10 TWh offshore</td>
<td>---</td>
</tr>
<tr>
<td>Switzerland</td>
<td>22.6 TWh/yr by 2050</td>
<td>4.0 TWh/yr by 2050 (0.6 TWh by 2020, 1.5 TWh by 2035)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>15% increase by 2020</td>
<td>---</td>
</tr>
<tr>
<td>United States</td>
<td>80% of electricity from clean sources by 2035</td>
<td>---</td>
</tr>
</tbody>
</table>

--- = No data available

IEA Wind
MW), and the United Kingdom (974 MW). The UK offshore wind capacity grew 79% and the country now has more than 1,000 wind turbines operating offshore.

In the EU, 2013 was a record year for offshore wind energy installations, with 1.57 GW of new capacity connected to the grid. Offshore wind power installations represented 14% of the annual EU wind energy market, up from 10% in 2012. The EWEA documented 22 GW of consented offshore wind farms in Europe and identified plans for offshore wind farms totaling more than 133 GW.

Outside of Europe, many countries are planning to expand capacity with offshore wind. In Japan, half of the new capacity installed for the year was located offshore. In Korea, construction is underway for the 100-MW first phase of a 2.5-GW offshore wind farm designed to demonstrate the technology and the quality of the site. In the United States, 14 offshore wind projects representing more than 5 GW of capacity were in various stages of development in 2013.

Several countries have set targets for offshore wind deployment: China, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, and the United States (Table 4). Finland issued a tender for an offshore demonstration wind power plant in 2013 that should be awarded in 2014.

China is active in offshore wind deployment worldwide. In 2013, a Chinese entity designed and built a set of jack-up installation vessels for a Danish wind turbine company. The vessel integrates the functions of transport, crane lifting, and installation of wind turbine components and can be used to install ten sets of wind turbines from 5 MW to 7 MW capacities.

In Denmark, the Megawind partnership released a roadmap in 2013 for the country to supply competitive offshore wind solutions. Offshore wind is seen as the next area for expansion of wind development in most countries with coastlines or active wind turbine and wind plant supply chains. National and cooperative research and development efforts are being focused on technology for this application (Section 4 and Table 16).

### 2.3 National incentive programs
All IEA Wind member countries have government or market structures designed to encourage renewable energy development. Most of these incentives also apply to wind energy (Table 11). The EU Emissions Trading System cap on carbon dioxide emissions will encourage the move to renewables, including wind energy (Carbon Trust 2014). Feed-in tariffs were used by 14 of the IEA Wind member countries to encourage wind development. They are reported to be very effective tools in that regard. Also popular with the IEA Wind member countries are programs that mandate utilities to supply a portion of electricity from renewables. Eleven countries use these utility obligations, renewable obligations, or renewable portfolio standards.

Some countries report that changes to existing incentive programs reduced wind deployment in 2013: Italy, Portugal, Spain, and the United States. In other countries, stable policies and new incentives are encouraging deployment: Australia, Canada, China, Denmark, Germany, Korea, Mexico, Norway, Sweden, and the United Kingdom.

### 2.4 Issues affecting growth
At the end of 2013, an estimated 184.6 GW in new wind plants were planned and/or under construction in the 14 reporting IEA Wind member countries (Table 12). The actual increases in capacity for 2014 and beyond will depend on resolution of the issues in the following
<table>
<thead>
<tr>
<th>Country</th>
<th>2012 capacity (MW)</th>
<th>2013 new capacity (MW)</th>
<th>Increase (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>288</td>
<td>190</td>
<td>67</td>
</tr>
<tr>
<td>México</td>
<td>1,212</td>
<td>426</td>
<td>35</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>8,292</td>
<td>2,422</td>
<td>29</td>
</tr>
<tr>
<td>Canada</td>
<td>6,201</td>
<td>1,599</td>
<td>26</td>
</tr>
<tr>
<td>Australia</td>
<td>2,584</td>
<td>655</td>
<td>25</td>
</tr>
<tr>
<td>Sweden</td>
<td>3,524</td>
<td>862</td>
<td>24</td>
</tr>
<tr>
<td>Austria</td>
<td>1,378</td>
<td>309</td>
<td>22</td>
</tr>
<tr>
<td>Switzerland</td>
<td>49</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>China</td>
<td>75,324</td>
<td>16,089</td>
<td>21</td>
</tr>
<tr>
<td>Denmark</td>
<td>4,162</td>
<td>644</td>
<td>16</td>
</tr>
<tr>
<td>Korea</td>
<td>487</td>
<td>74</td>
<td>15</td>
</tr>
<tr>
<td>Norway</td>
<td>704</td>
<td>98</td>
<td>14</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,431</td>
<td>281</td>
<td>12</td>
</tr>
<tr>
<td>Germany</td>
<td>31,315</td>
<td>3,356</td>
<td>11</td>
</tr>
<tr>
<td>Greece</td>
<td>1,749</td>
<td>116</td>
<td>7</td>
</tr>
<tr>
<td>Ireland</td>
<td>1,827</td>
<td>133</td>
<td>7</td>
</tr>
<tr>
<td>Italy</td>
<td>8,144</td>
<td>434</td>
<td>5</td>
</tr>
<tr>
<td>Portugal</td>
<td>4,517</td>
<td>192</td>
<td>4</td>
</tr>
<tr>
<td>Japan</td>
<td>2,614</td>
<td>56</td>
<td>2</td>
</tr>
<tr>
<td>United States</td>
<td>60,007</td>
<td>1,087</td>
<td>2</td>
</tr>
<tr>
<td>Spain</td>
<td>22,785</td>
<td>175</td>
<td>1</td>
</tr>
</tbody>
</table>

* % increase = (new capacity 2013/ capacity in 2012) x 100

**Bold italic** indicates estimate

<table>
<thead>
<tr>
<th>High wind Country (index %)</th>
<th>Average wind Country (index %)</th>
<th>Low wind Country (index %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy (103%)</td>
<td>Austria</td>
<td>Denmark</td>
</tr>
<tr>
<td>Portugal</td>
<td>China</td>
<td>Germany (97.8%)</td>
</tr>
<tr>
<td>Spain</td>
<td>Finland (102%)</td>
<td>the Netherlands (91%)</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>United States*</td>
<td></td>
</tr>
</tbody>
</table>

The average wind year = 100%

* Regional resources vary across the continent in any year

Policy:
Changing policies increase risk for project developers, reducing the number of new projects proposed. Government programs to increase access to financing, provide larger feed-in tariffs, increase tax benefits, and provide targeted grants are mentioned as ways to reduce the effects of policy uncertainty. In Italy, Portugal, Spain, Switzerland, the United Kingdom, and the United States, government cost-cutting measures have targeted funds allocated for incentive programs. In Italy, establishment of a low quota of wind capacity that can benefit from incentives resulted in a 66% drop in annual wind installations for 2013. In the United Kingdom, two planned offshore projects were withdrawn in response to incentive scheme changes. In the United States, incentive changes resulted in a 92% drop in annual wind installations for 2013.

Economic climate:
Reduced electrical demand as a result of the economic slowdown (and possibly energy conservation) has resulted in overcapacity or at least lack of pressure to increase generation capacity in countries including Portugal, Spain, and the United States.

Shortage of sites on land:
A shortage of onshore wind sites was cited in some countries; Denmark, Germany, Japan, Korea, the Netherlands, and the United Kingdom; as a reason to develop offshore wind projects. In the Netherlands, wind sites on land are shifting from stand-alone turbines to wind farms. Many provinces forbid the installation of stand-alone turbines and even upgrading existing ones. Due to the high population density, space for wind farms is limited.

Grid integration and capacity issues:
In many countries, the electrical grids are adapted to the needs of centralized, large-scale power plants. Their capacity is limited to existing generation and demand. Some of these systems must absorb large amounts of wind power. Curtailment occurs when grid operators shut down wind farms to balance generation and demand. Improved forecasting and grid upgrades are addressing this problem. Additionally, requirements imposed by grid operators are reported to increase project costs.

Several countries made progress in upgrading or adding transmission lines to carry wind capacity. In Italy, wind production curtailments in 2013 were less than 1% compared to more than 5% in 2010. In China, the average curtailment rate for wind power decreased by 11% in 2013. In Japan, wind power development will be enhanced by a 50% subsidy to reinforce the grid system in high-wind areas with limited grid capacity. In México, a new transmission line has been commissioned to an area where annual wind capacity factors could reach 40%. In the United States, a large new transmission project capable of transmitting more than 18 GW of wind energy was completed in Texas.

Permitting process:
Permitting requirements for wind development in several countries can be lengthy.
### Table 8. Percent Contribution of Wind to National Electricity Demand 2010–2013*

<table>
<thead>
<tr>
<th>Country</th>
<th>2010 (%)</th>
<th>2011 (%)</th>
<th>2012 (%)</th>
<th>2013 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>21.9</td>
<td>28.0</td>
<td>29.9</td>
<td>32.7</td>
</tr>
<tr>
<td>Portugal</td>
<td>17.0</td>
<td>18.0</td>
<td>20.0</td>
<td>23.5</td>
</tr>
<tr>
<td>Spain</td>
<td>16.4</td>
<td>16.3</td>
<td>17.8</td>
<td>20.9</td>
</tr>
<tr>
<td>Ireland</td>
<td>10.5</td>
<td>15.6</td>
<td>14.5</td>
<td>16.3</td>
</tr>
<tr>
<td>Germany</td>
<td>6.0</td>
<td>7.6</td>
<td>7.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.6</td>
<td>4.4</td>
<td>5.0</td>
<td>7.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.6</td>
<td>4.2</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Austria</td>
<td>3.0</td>
<td>3.6</td>
<td>5.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Greece**</td>
<td>4.0</td>
<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Italy</td>
<td>2.6</td>
<td>3.0</td>
<td>4.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4.0</td>
<td>4.2</td>
<td>4.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Australia**</td>
<td>2.0</td>
<td>2.4</td>
<td>3.4</td>
<td>4.1</td>
</tr>
<tr>
<td>United States</td>
<td>2.3</td>
<td>2.9</td>
<td>3.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Canada</td>
<td>1.8</td>
<td>2.3</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>China</td>
<td>1.2</td>
<td>1.6</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>México</td>
<td>0.6</td>
<td>0.6</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Norway</td>
<td>0.7</td>
<td>1.0</td>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Finland</td>
<td>0.3</td>
<td>0.6</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Japan</td>
<td>0.4</td>
<td>0.5</td>
<td>0.54</td>
<td>0.5</td>
</tr>
<tr>
<td>Korea</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Overall of IEA Wind Member Countries</td>
<td>2.3</td>
<td>2.8</td>
<td>3.3</td>
<td>3.86</td>
</tr>
</tbody>
</table>

*Percent of national electricity demand from wind = (wind generated electricity / national electricity demand) × 100

** (GWEC 2014)

**Bold italic** = indicates estimate

---

Finland, local and regional planning to designate areas for wind development is helping to shorten the permitting process. Conflicts with aviation, radar, and railways are being addressed with procedures and modeling tools that identify cost-effective solutions, such as updating radar or television hardware. Environmental impact assessments can take months or years to complete. In Japan, the environmental impact assessment (EIA) process required since 2012 can take two to three years to complete and has delayed several projects. However, five wind farm projects with total capacity of 174 MW have finished the EIA procedure, and the impact assessment of more than 80 projects with about 4,700 MW are now in progress. In the Netherlands, a National Coordination Regulation stipulates that for wind energy projects of greater than 100 MW, the national government will automatically take over procedures and deal with the permissions. This regulation coordinates and shortens procedures and is meant to speed up employment.

**Environmental impacts:**

Concerns about environmental impact were also mentioned as issues affecting the permitting of new wind projects. Research projects on environmental impact are underway in most countries. The new IEA Wind Task 34 Environmental Impacts and Assessment will leverage the findings of these projects for the task participants.

In Finland, noise is being addressed by increased measurement programs, curtailed operation, and hardware replacement where necessary. Noise and shadow flicker (when the operating turbine blades cast shadows on the observer) have been addressed in Ireland with draft revised guidelines.

**Social acceptance:**

Social acceptance is becoming an issue in nearly every country that has wind development. IEA Wind Task 28 Social Acceptance of Wind Energy Projects is addressing the process of wind project development. The Sustainable Energy Authority of Ireland published the “Methodology for Local Authority Renewable Energy Strategies” in 2013 that provides a methodology for identifying areas suitable for wind energy development. It has been adopted by several local authorities in preparing their renewable energy strategies.

---

### Table 9. National Electricity Demand and Percent Contribution from Wind in 2013*

<table>
<thead>
<tr>
<th>Country</th>
<th>National electricity demand (TWH/yr)</th>
<th>National electricity demand from wind* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>5,245.1</td>
<td>2.6%</td>
</tr>
<tr>
<td>United States</td>
<td>4,058.2</td>
<td>4.1%</td>
</tr>
<tr>
<td>Japan</td>
<td>845.5</td>
<td>0.5%</td>
</tr>
<tr>
<td>Germany</td>
<td>600.1</td>
<td>8.9%</td>
</tr>
<tr>
<td>Canada</td>
<td>560.0</td>
<td>3.1%</td>
</tr>
<tr>
<td>Korea</td>
<td>532.2</td>
<td>0.2%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>375.9</td>
<td>6.0%</td>
</tr>
<tr>
<td>Italy</td>
<td>317.1</td>
<td>4.7%</td>
</tr>
<tr>
<td>Spain</td>
<td>260.0</td>
<td>20.9%</td>
</tr>
<tr>
<td>México</td>
<td>249.0</td>
<td>1.5%</td>
</tr>
<tr>
<td>Australia**</td>
<td>226.0</td>
<td>4.1%</td>
</tr>
<tr>
<td>Sweden</td>
<td>139.0</td>
<td>7.0%</td>
</tr>
<tr>
<td>Norway</td>
<td>129.2</td>
<td>1.5%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>120.3</td>
<td>4.7%</td>
</tr>
<tr>
<td>Finland</td>
<td>83.9</td>
<td>0.9%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>63.7</td>
<td>0.2%</td>
</tr>
<tr>
<td>Austria</td>
<td>62.0</td>
<td>5.8%</td>
</tr>
<tr>
<td>Greece**</td>
<td>57.0</td>
<td>5.8%</td>
</tr>
<tr>
<td>Portugal</td>
<td>50.6</td>
<td>23.5%</td>
</tr>
<tr>
<td>Denmark</td>
<td>34.0</td>
<td>32.7%</td>
</tr>
<tr>
<td>Ireland</td>
<td>27.9</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

Totals/Average | 14,037.5 | 3.86%

*Percent of national electricity demand from wind = (wind generated electricity / national electricity demand) × 100

** (GWEC 2014)

**Bold italic** indicates estimate
Equitable distribution regarding the export of wind project electricity has been an issue in Ireland. In México equitable treatment of wind land owners needs to be addressed. Canadian provinces have addressed this distribution issue with community funds set up by developers, administered by foundations, and distributed to affected communities for projects to improve the community, health, youth education, and other causes.

3.0 Implementation

3.1 Economic impact

Key impacts of wind energy development include providing employment, bringing economic activity to project sites and supply chain entities, stimulating domestic manufacturing, and enhancing export of wind turbines, components, and consulting expertise. Even countries with no domestic turbine manufacturers have export markets attributed to wind energy.

Table 13 shows reported labor and economic turnover effects for 2013 in the reporting IEA Wind member countries. The United States reported fewer jobs in 2013, while nine countries reported an increase in jobs in 2013: Austria, China, Finland, Germany, Japan, Korea, the Netherlands, Spain, and the United Kingdom. Five countries reported no change in employment in 2013: Denmark, Ireland, Italy, México, and Portugal.

In Ireland, a model of the Irish economy has been developed to assess the economic impacts of investment in renewable energy and energy efficiency. In a scenario where 32% of electricity is supplied by wind energy by 2020, gross domestic product would increase by 314 million EUR (433 million USD) (2012 prices) with 2,969 net new jobs that year.

One of the positive effects of wind generation is displacing fossil fuel consumption by the power sector and the related economic and environmental costs. Most countries calculate the avoided emissions attributable to wind energy and the number of households supplied with electricity generated by wind turbines. These calculations are based on the generation mix and usage patterns of each country reporting. In the United States, the highest producer of wind-generated electricity, the 167.7 GWh produced meant that nearly 96 million tons of carbon dioxide were not emitted into the atmosphere; this was equivalent to reducing power system emissions by 4.4%. In China, the 137.1 TWh produced could satisfy the electrical needs of 62.75 million Chinese households.

3.2 Industry status

Wind projects are owned by utilities, cooperatives, independent power producers (IPPs), private companies (i.e., industries for self-supply), income funds, and communities (including First Nations in Canada and the United States). Many details are presented in the country chapters of this report. A few examples are included here.

In Canada, a wind turbine owned and operated by a labor union began production after nine years of planning, preparation, construction, and testing. The 500-kW turbine on the grounds of the union’s Family Education Centre will generate the equivalent of 50%–60% of the center’s current energy needs.

In México, several wind energy projects share electricity with both big- and medium-sized electricity consumers under self-supply consortiums. CEMEX, a global leader in the building materials industry, is using wind energy to supply its activities. Another 10-MW wind energy project is supplying electricity for public municipal lighting in México.

The economic downturn has had widely publicized effects on wind turbine suppliers. For example, in the United States, the number of wind turbine suppliers fell from 28 in 2012 to 7 in 2013.

3.3 Operational details

Wind plants composed of many individual wind turbines are becoming more productive by several measures, one of which is capacity factor. The annual capacity factor is the amount of energy a generating plant produces over the year divided by the amount of energy that would have been produced if the plant had been running at full capacity during that same time interval. For wind turbines, capacity factor is dependent on the quality of the wind resource, the availability of the machine to generate when there is enough wind (i.e., its reliability), and the size of the generator. The capacity factor is reduced if the utility curtails production due to load management needs. Most wind power plants operate at a capacity factor of 25%–40%. Offshore wind turbines generally have higher capacity factors due to large rotors (long blades) and excellent winds. The IEA Wind member countries’ estimated average annual capacity factors for 2013 are in Table 14.

The IEA Wind member countries report a trend of installing low-wind-speed turbines that have taller towers, longer blades, and comparatively smaller generators. These turbines allow wind development in more areas, including those with lower wind speeds or forests, resulting in better performance.

In the Netherlands, despite the low wind index of 91% (compared to average index of 100%) in 2013, average turbines on land are currently performing better than before. Key reasons are the increased average hub height and the increased area swept by the rotor, resulting in a better performance of wind turbines.

### Table 10. Offshore Wind Energy Capacity in IEA Wind Member Countries 2011–2013

<table>
<thead>
<tr>
<th>Country</th>
<th>2011 Capacity (MW)</th>
<th>2012 Capacity (MW)</th>
<th>2013 Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>1,838</td>
<td>2,679</td>
<td>3,653</td>
</tr>
<tr>
<td>Denmark</td>
<td>871</td>
<td>920</td>
<td>1,271</td>
</tr>
<tr>
<td>Germany</td>
<td>200</td>
<td>280</td>
<td>903</td>
</tr>
<tr>
<td>China</td>
<td>108</td>
<td>390</td>
<td>428</td>
</tr>
<tr>
<td>Netherlands</td>
<td>228</td>
<td>228</td>
<td>228</td>
</tr>
<tr>
<td>Japan</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Finland</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Ireland</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Korea</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Norway</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Portugal</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>3,325</td>
<td>4,579</td>
<td>6,590</td>
</tr>
<tr>
<td>Type of program</td>
<td>Description</td>
<td>Countries implementing</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Carbon tax</td>
<td>A tax on carbon that encourages a move to renewables and provides investment dollars for renewable projects.</td>
<td>The EU emissions trading system (EU ETS) - international system for trading GHG emission allowances, covers more than 11,000 power stations, industrial plants, and airlines in 31 countries.</td>
<td></td>
</tr>
<tr>
<td>Feed-in tariff</td>
<td>An explicit monetary reward for wind-generated electricity that is paid (usually by the electricity utility) at a guaranteed rate per kilowatt-hour that may be higher than the wholesale electricity rates paid by the utility. Special definition in Finland and the Netherlands: Subsidy is the difference between a guaranteed price and the electricity market price—producers are in the electricity markets.</td>
<td>Austria, Canada, China, Denmark (offshore fixed from project to project and small wind turbines), Finland (special definition), Germany, Ireland, Italy, Japan, Korea, the Netherlands (special definition), Portugal, Switzerland, United Kingdom (14 countries)</td>
<td></td>
</tr>
<tr>
<td>Renewable portfolio standards (RPS), renewables production obligation (RPO), or renewables obligation (RO)</td>
<td>Mandate that the electricity utility (often the electricity retailer) source a portion of its electricity supplies from renewable energies.</td>
<td>Canada, China, Italy, Japan (until June 2012), Korea, Norway, Portugal, Sweden, United Kingdom, United States (11 countries)</td>
<td></td>
</tr>
<tr>
<td>Green electricity schemes</td>
<td>Green electricity based on renewable energy from the electric utility, which can be purchased by customers, usually at a premium price.</td>
<td>Austria, Canada, Denmark, Finland, Netherlands, Norway, Sweden, Switzerland, United States (9 countries)</td>
<td></td>
</tr>
<tr>
<td>Special incentives for small wind</td>
<td>Reduced connection costs, conditional planning consent exemptions. Value-added tax (VAT) rebate for small farmers. Accelerated capital allowances for corporations. Can include microFIT.</td>
<td>Canada, Denmark, Ireland, Italy, Japan (from July 2012), Portugal, United States (7 countries)</td>
<td></td>
</tr>
<tr>
<td>Electric utility activities</td>
<td>Activities include green power schemes, allowing customers to purchase green electricity, wind farms, various wind generation ownership and financing options with select customers, and wind electricity power purchase models.</td>
<td>Canada, Denmark, Finland, Ireland (Including voluntary supplier tariff for domestic micro-wind), Sweden, Switzerland, United States (7 countries)</td>
<td></td>
</tr>
<tr>
<td>Spatial planning activities</td>
<td>Areas of national interest that are officially considered for wind energy development.</td>
<td>China, Denmark, Korea, México, the Netherlands, Norway, Sweden, Switzerland (8 countries)</td>
<td></td>
</tr>
<tr>
<td>Net metering or net billing</td>
<td>The system owner receives retail value for any excess electricity fed into the grid, as recorded by a bi-directional electricity meter and netted over the billing period. Electricity taken from the grid and electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price.</td>
<td>Canada, Denmark, Italy, Netherlands (small wind only), Portugal (micro-generation only), United States (6 countries)</td>
<td></td>
</tr>
<tr>
<td>Income tax credits</td>
<td>Some or all expenses associated with wind installation that may be deducted from taxable income streams.</td>
<td>Canada, Ireland, México, Netherlands, United States (5 countries)</td>
<td></td>
</tr>
<tr>
<td>Investment funds for wind energy</td>
<td>Share offerings in private wind investment funds are provided, plus schemes that focus on wealth creation and business success using wind energy as a vehicle to achieve these ends.</td>
<td>Canada, Ireland, Netherlands, Switzerland, United Kingdom (5 countries)</td>
<td></td>
</tr>
<tr>
<td>Sustainable building requirements</td>
<td>The requirements of new building developments (residential and commercial) to generate a prescribed portion of their heat and/or electricity needs from on site renewable sources (e.g., wind, solar, biomass, geothermal). Existing buildings can qualify for financial incentives to retrofit renewable technologies.</td>
<td>Denmark (solar), Ireland, Korea, Portugal (4 countries)</td>
<td></td>
</tr>
<tr>
<td>Green certificates</td>
<td>Approved power plants receive certificates for the amount (MWh) of electricity they generate from renewable sources. They sell electricity and certificates. The price of the certificates is determined in a separate market where demand is set by the obligation of consumers to buy a minimum percentage of their electricity from renewable sources.</td>
<td>Norway, Sweden, and United Kingdom (3 countries)</td>
<td></td>
</tr>
<tr>
<td>Capital subsidies</td>
<td>Direct financial subsidies aimed at the up-front cost barrier, either for specific equipment or total installed wind system cost.</td>
<td>Canada, China, Korea (3 countries)</td>
<td></td>
</tr>
</tbody>
</table>

1. Executive Summary
ratio of large wind capture area to the generator rating.

In Finland, new projects with towers up to 140 m high are seen in forested inland locations. High towers and new designs with larger rotors provide considerably higher capacity factors than previously experienced in Finland, increasing from 20%–23% to 26%–35%. For the 33 turbines with a hub height of 100 m or more, the average capacity factor was 31% and the maximum capacity factor was 48%.

In Germany, the rather weak wind resource year was partially compensated by installations of larger turbines and above-average rotor diameters for wind energy generators on land and new capacity offshore. This combination led to an average capacity factor that is only slightly below the long-term average. Tall turbines with very large rotor diameters and relatively small generators have been installed primarily in southern German states to better exploit lower wind speeds.

In Japan, Hitachi developed a new 2-MW, downwind wind turbine, the HTW2.0-86. It is a low-wind-speed version of HTW2.0-80 with longer rotor blades.

In Switzerland, new projects with modern wind turbines are showing substantially higher performance. The average capacity factor for installations in Switzerland has increased to about 20%.

In the United States, of the 582 turbines installed in 2013, 437 had rotors with diameters of 100 m or larger.

The move to offshore deployment, replacing older, smaller machines and developing large wind plants, led to a higher average power rating of new wind turbines installed in 2013 in 13 countries: Canada, China, Denmark, Finland, Italy, Korea, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland. The average power rating of new turbines was lower in 2013 than in 2012 in Austria, Japan, and the United States.

### Table 12. Potential Increases to Capacity in IEA Wind Member Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Planning approval* (MW)</th>
<th>Under construction** (MW)</th>
<th>Total planned and/or under construction (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Austria</td>
<td>400</td>
<td>483</td>
<td>883</td>
</tr>
<tr>
<td>Canada (by 2016)</td>
<td>4,500</td>
<td>---</td>
<td>4,500</td>
</tr>
<tr>
<td>China</td>
<td>18,000</td>
<td>60,230</td>
<td>78,230</td>
</tr>
<tr>
<td>Denmark (Anholt)</td>
<td>---</td>
<td>---</td>
<td>3,300</td>
</tr>
<tr>
<td>Finland</td>
<td>224</td>
<td>195</td>
<td>419</td>
</tr>
<tr>
<td>Germany (offshore)</td>
<td>6,800</td>
<td>2,300</td>
<td>9,100</td>
</tr>
<tr>
<td>Greece</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ireland</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Japan</td>
<td>174</td>
<td>---</td>
<td>4,719</td>
</tr>
<tr>
<td>Korea</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>México</td>
<td>3,022</td>
<td>316</td>
<td>3,438</td>
</tr>
<tr>
<td>Netherlands</td>
<td>---</td>
<td>---</td>
<td>On land: 1,064 Offshore: 745</td>
</tr>
<tr>
<td>Norway</td>
<td>3,064</td>
<td>45</td>
<td>3,109</td>
</tr>
<tr>
<td>Portugal</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Spain</td>
<td>---</td>
<td>---</td>
<td>177</td>
</tr>
<tr>
<td>Sweden</td>
<td>6,426</td>
<td>1,434</td>
<td>7,860</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>37,191</td>
<td>17,890</td>
<td>55,081</td>
</tr>
<tr>
<td>United States</td>
<td>---</td>
<td>12,000+</td>
<td>12,000+</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>184,625</td>
</tr>
</tbody>
</table>

--- = no data available
*
Projects have been approved by all planning bodies.
** Projects have been approved by all planning bodies.

### 3.4 Wind energy costs

The cost of electricity from wind generation is declining, according to the IEA Wind member countries. IEA Wind Task 26 is addressing this key metric, often referred to as the levelized cost of energy or LCOE, by collecting data on system and project costs, assessing methodologies for projecting future wind technology costs, and surveying methods for determining the value of wind energy (Lantz et al. 2012). The individual country chapters include estimated costs of energy based on local conditions.

The trend toward using turbines on taller towers with larger rotors for a given generator capacity is working to reduce the LCOE by extracting more energy from a given site. Ireland reports that the newer
large-roter, low-specific-power models represent the upper end of the cost range for turbines and projects. However, because these turbines yield a higher energy capture per rated kilowatt of the generator, they will allow a continued reduction in the cost of wind energy.

The country chapters also address costs for turbines, development, operation and maintenance in some detail. Table 15 shows costs since 2003 as reported by IEA Wind member countries. Please note that the historic cost numbers (2003 to 2012) have not been corrected to 2013 currency.

### 4.0 Research, Development, and Deployment (R,D&D) Activities

A significant benefit to countries that join the IEA Wind agreement is that relevant organizations within the country can participate in the co-operative research tasks. In 2013, 13 active research tasks sponsored by IEA Wind were advancing wind energy technology and deployment. To guide these activities, the Executive Committee of IEA Wind agreement prepared a new Strategic Plan 2014–2019. This plan is based on the document Long-term Research and Development Needs for Wind Energy for the Time Frame 2012 to 2030, approved by the IEA Wind members in 2012. Figure 3 lists the task activities and their time frames. Any task may be extended beyond the endpoint in the figure if the participants agree and the Executive Committee approves the work plan. New tasks are added as the member countries agree on new research topics for cooperation. For example, a new task was added in 2013 for ground-based testing, Task 35.

### 4.1 National R, D&D efforts

The major research areas discussed in the individual country chapters are listed in Table 16. The country chapters contain references to recent reports and databases resulting from this research. One clear trend is that most countries with shorelines are placing a high priority on research to support offshore wind technology (Denmark, China, Finland, Germany, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States).

Government research support contributes to the advancement of wind technology and deployment. It is difficult to calculate the total funds for research supporting wind energy technology. However, Table 17 lists government budgets for wind R&D reported by some countries. Investments from research partners in industry and academia also contribute to advancing wind energy deployment.

A clear trend in Canada, México, the Netherlands, and the United Kingdom is that national R&D is increasingly directed by the business sector, research centers, and universities rather than by political and governmental organizations. Newly-designed programs strive to have the R&D community work more in line with requests from the industrial sector; while the industrial sector is encouraged to make more use of the knowledge available in the research centers and universities.

Another effective approach in R&D planning is to develop or update a national or industry wind technology roadmap. Roadmaps summarize the status, assesses needs, sets priorities, and call out key actions needed to increase the contribution of wind energy to electricity generation (Austria, Japan, Portugal, and the United States.)

The European Commission is a significant source of funding for wind energy research projects proposed by EU countries. In 2013, 18 wind R&D projects were started with the support of the EU’s Seventh Framework Programme (FP7). Framework Programmes are the main EU-wide tool to support strategic research areas. These projects run from two to four years.

Outside of Europe, IEA Wind member countries establish their research priorities and benefit from cooperation in the IEA Wind research tasks. For more information on test centers and research activities, please refer to the country chapters and the chapter from the European Commission/European Wind Energy Association. A few highlights are presented here.

### Table 13. Capacity in Relation to Estimated Jobs and Economic Impact 2013

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity (MW)</th>
<th>Estimated number of jobs</th>
<th>Economic impact (million EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>91,413</td>
<td>360,000</td>
<td>13,100</td>
</tr>
<tr>
<td>United States</td>
<td>61,110</td>
<td>50,500</td>
<td>86,000</td>
</tr>
<tr>
<td>Germany</td>
<td>34,660</td>
<td>137,800</td>
<td>8,500</td>
</tr>
<tr>
<td>Spain</td>
<td>22,959</td>
<td>&gt;20,000</td>
<td>2,623</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10,861</td>
<td>16,500</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>8,554</td>
<td>30,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Canada</td>
<td>7,803</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Denmark</td>
<td>4,808</td>
<td>23,000</td>
<td>7,400</td>
</tr>
<tr>
<td>Portugal</td>
<td>4,709</td>
<td>3,200</td>
<td>---</td>
</tr>
<tr>
<td>Sweden</td>
<td>4,469</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Australia</td>
<td>3,239</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,709</td>
<td>2,200</td>
<td>800</td>
</tr>
<tr>
<td>Japan</td>
<td>2,670</td>
<td>3,300</td>
<td>1,297</td>
</tr>
<tr>
<td>Ireland</td>
<td>1,896</td>
<td>2,200</td>
<td>---</td>
</tr>
<tr>
<td>Greece</td>
<td>1,865</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Austria</td>
<td>1,684</td>
<td>4,500</td>
<td>1,180</td>
</tr>
<tr>
<td>México</td>
<td>1,551</td>
<td>1,500</td>
<td>435</td>
</tr>
<tr>
<td>Norway</td>
<td>811</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Korea</td>
<td>561</td>
<td>2,366</td>
<td>1,010</td>
</tr>
<tr>
<td>Finland</td>
<td>448</td>
<td>3,000</td>
<td>930</td>
</tr>
<tr>
<td>Switzerland</td>
<td>60</td>
<td>---</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>268,840</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Applicable conversion rate EUR to USD: 1.378
--- = No data available
4.1.1 New test, research, and demonstration facilities

Several important new research centers were opened, under construction, or being planned in 2013.

In Canada, the Wind Energy Institute commissioned a new Wind R&D Park in April 2013 that will be able to demonstrate the benefit of energy storage under various scenarios. The Wind Park features generating capacity of 10 MW and incorporates a battery energy storage system.

A Canadian company is working with the utility Hydro One to provide up to ten 500-kW flywheels for frequency regulation on a feeder that is connected to two 10-MW wind farms in southwest Ontario. The 9,000-pound solid-steel flywheel will provide about three to fifteen minutes of storage and millisecond-level responses to balance wind ramping, starting in 2014. Ontario’s Independent Electricity System Operator will also gain 2 MW of regulation service by integrating flywheel technology into its province’s grid.

In China, an icing wind tunnel (3m x 2m) in China’s Aerodynamics Research & Development Center began operation and completed the NACA0012 airfoil iced model tests. Designed for aircraft component testing, it can also be used for wind turbine blade materials and provides the variable pressure icing cloud environment of low and high temperature for icing tests.

In Denmark, at the Lindoe Offshore Renewables Center, planning continues, and funding is now guaranteed. There will be two test beds for nacelle assemblies of up to 10 MW.

Aerocoustics, an engineering firm based in Ontario, Canada, received accreditation to perform testing to IEC 61400-11, Wind Turbine Generator Systems–Acoustic Noise Measurement Techniques. Construction of the German facilities for testing nacelles in Bremerhaven, support structures in Hanover, and power drives in Aachen continued in 2013 with operations to begin in 2014.

In the United Kingdom, the National Renewable Energy Centre (Narec), opened a 15-MW drive train test facility for offshore wind turbines in 2013. Once final commissioning is complete, it will test Samsung Heavy Industries’ 7-MW nacelle assembly. In 2013, Narec was granted planning consents for a 99-MW offshore wind demonstration site in deep water and for an onshore substation on the coast of Blyth, Northumberland. Samsung Heavy Industries erected its 7-MW demonstrator turbine, as part of the Methil Offshore Wind Demonstration Farm in Scotland.

The United States opened three new research and testing facilities in 2013: a 7.5-MW and a 15-MW dynamometer capable of testing wind turbine drive trains up to 15 MW; a 5-MW dynamometer test facility that can test drivetrains up to 5 MW; and the first U.S. test facility specifically designed to understand the complex wind flow and wakes within a wind plant. This third new test facility has three research-scale wind turbines spaced and oriented to study turbine-to-turbine interactions.

In the United States, a concrete-composite floating platform wind turbine (1:8th-scale 20-kW) was installed off the coast of Maine to validate coupled aero-elastic/hydrodynamic computer models for floating offshore wind turbines and to better understand the dynamic response behavior of floating offshore wind systems.
### Table 14. Reported Average Capacity Factors 2011–2013 (%)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Average capacity factor 2011 (%)</th>
<th>Average capacity factor 2012 (%)</th>
<th>Average capacity factor 2013 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>---</td>
<td>35.0</td>
<td>---</td>
</tr>
<tr>
<td>Austria</td>
<td>---</td>
<td>30.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Canada</td>
<td>31.0</td>
<td>31.0</td>
<td>31.0</td>
</tr>
<tr>
<td>China</td>
<td>---</td>
<td>18.4</td>
<td>23.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>28.4</td>
<td>22.6</td>
<td>27.1</td>
</tr>
<tr>
<td>Finland</td>
<td>28.0</td>
<td>24.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Germany</td>
<td>19.0</td>
<td>---</td>
<td>18.5</td>
</tr>
<tr>
<td>Greece</td>
<td>---</td>
<td>---</td>
<td>27.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>31.6</td>
<td>28.4</td>
<td>30.5</td>
</tr>
<tr>
<td>Italy</td>
<td>18.0</td>
<td>---</td>
<td>21.0</td>
</tr>
<tr>
<td>Japan</td>
<td>19.0</td>
<td>19.9</td>
<td>17.0</td>
</tr>
<tr>
<td>Korea</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>México</td>
<td>30.0</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Netherlands</td>
<td>---</td>
<td>On land 20.0 Offshore 39.5</td>
<td>On land 22.0 Offshore 38.6</td>
</tr>
<tr>
<td>Norway</td>
<td>31.3</td>
<td>31.2</td>
<td>29.2</td>
</tr>
<tr>
<td>Portugal</td>
<td>26.0</td>
<td>28.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Spain</td>
<td>---</td>
<td>24.1</td>
<td>26.9</td>
</tr>
<tr>
<td>Sweden</td>
<td>---</td>
<td>26.0</td>
<td>28.3</td>
</tr>
<tr>
<td>Switzerland</td>
<td>20.0</td>
<td>&lt;20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Onshore 27.4 Offshore 36.7</td>
<td>On land 27.4 Offshore 36.7</td>
<td>---</td>
</tr>
<tr>
<td>United States</td>
<td>33.0</td>
<td>33.0</td>
<td>32.1</td>
</tr>
</tbody>
</table>

* The amount of energy the plant produces over the year divided by the amount of energy that would have been produced if the plant had been running at full capacity during that same time interval. These are all estimated numbers.  
--- = No data available

### Table 15. Estimated Average Turbine Cost and Total Project Cost for 2013

<table>
<thead>
<tr>
<th>Country</th>
<th>Turbine cost (EUR/kW**)</th>
<th>Total installed project cost* (EUR/kW**)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1,390</td>
<td>1,715</td>
</tr>
<tr>
<td>Canada</td>
<td>---</td>
<td>1,639</td>
</tr>
<tr>
<td>China</td>
<td>480</td>
<td>960</td>
</tr>
<tr>
<td>Denmark</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Finland</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Germany</td>
<td>1,053</td>
<td>1,427</td>
</tr>
<tr>
<td>Greece</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ireland</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>1,200</td>
<td>1,750</td>
</tr>
<tr>
<td>Japan</td>
<td>1,380</td>
<td>2,070</td>
</tr>
<tr>
<td>Korea</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>México</td>
<td>1,200</td>
<td>1,500</td>
</tr>
<tr>
<td>Netherlands</td>
<td>---</td>
<td>on land: 1,376 offshore: 3,200</td>
</tr>
<tr>
<td>Norway</td>
<td>912</td>
<td>1,412</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,080</td>
<td>1,350</td>
</tr>
<tr>
<td>Spain</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Sweden</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1,450</td>
<td>2,070</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>United States</td>
<td>653.40 to 943.80</td>
<td>---</td>
</tr>
</tbody>
</table>

* Total Installed Project Cost includes: costs for turbines, roads, electrical equipment, installation, development, and grid connection.  
** Applicable conversion rate EUR to USD: 1.378

--- = No data available

4.1.2 Highlights of research results

Details of these and other completed projects, references to the resulting publications, and planned R&D activities can be found in the country chapters of this report.

In Canada, TechnoCentre éolien collaborated with VTT Technical Research Centre of Finland to gather data on vibrations and ice from wind turbines at the Canadian research site and from wind turbines in Finland. The data showed that vibrations were more pronounced during ice events. Applying this result, the IEC is revising the guidelines for wind turbine design (IEC 61400-1) for cases involving loads associated with ice.

TechnoCentre éolien participated in the first market study dedicated to wind energy in cold climates. According to the report, 11.5 GW of the world’s wind energy capacity is installed in areas where moderate to heavy icing conditions occur—66% of which are in North America, 14% of which are in Quebec.

In Germany, the “StUKplus conference” by the Federal Maritime and Hydrographic Agency in 2013 dealt with lessons learned from five years of environmental monitoring and research on ecological effects at the offshore wind farm Alpha Ventus. The lessons of dealing with effects of offshore wind energy development to fish, benthos, birds, and marine mammals were also discussed. In that context, the standard for the “Investigation of GHG emission during the life cycle of the wind power supply chain is 15.9 to 18.7 CO_2 eg/kWh. Of this total, 75% was emitted during manufacture and 25% during construction and operation and maintenance.

In Germany, the “StUKplus conference” by the Federal Maritime and Hydrographic Agency in 2013 dealt with lessons learned from five years of environmental monitoring and research on ecological effects at the offshore wind farm Alpha Ventus. The lessons of dealing with effects of offshore wind energy development to fish, benthos, birds, and marine mammals were also discussed. In that context, the standard for the “Investigation of GHG emission during the life cycle of the wind power supply chain is 15.9 to 18.7 CO_2 eg/kWh. Of this total, 75% was emitted during manufacture and 25% during construction and operations and maintenance.
Figure 3. Priority area from IEA Wind Strategic Plan
<table>
<thead>
<tr>
<th>Type of program</th>
<th>Country activities reported</th>
<th>IEA Wind co-operative activities in 2013</th>
</tr>
</thead>
</table>
| Offshore wind                   | • Technology development and testing of turbines, including turbines up to 10 MW and foundations (fixed and floating)  
• Design work for turbines up  
  to 20 MW  
• Drive train advances  
• Transmission issues  
• Bigger blades  
• Innovative materials for blades, towers, and generators  
• Resource assessment  
• Reliability of operations and maintenance  
• Improvement of project development processes | Task 30 OC4 Comparison of Dynamic Codes and Models for Offshore Wind Energy (structures)                                                                                          |
| Wind farm modeling              | Data acquisition and model development                                                      | Task 31 WAKEBENCH: Benchmarking of Wind Farm Flow Models                                                                                                                                                                    |
| Small wind                      | • Technology development and testing of turbines generating 50 kW or less  
• Investigation of legal and social issues  
• Tools for siting in urban settings  
• Operation and maintenance costs reduction  
• Noise reduction  
• Assessing economics and usability | Task 27 Small Wind Turbine Labels for Consumers in conjunction with IEC MT2 standards work; Second term title for Task 27 is Small Wind Turbines at Turbulent Sites |
| Mid-sized wind                  | Technology development of turbines between 50 kW and 1 MW                                   |                                                                                                                                                                                                                           |
| Hybrid systems                  | • Wind with hydropower, biomass, diesel, and storage                                         |                                                                                                                                                                                                                           |
| Technology improvements         | • Two-bladed rotors, upwind and downwind designs, blade materials and design work, control systems  
• Applying systems engineering to improvements in components |                                                                                                                                                                                                                           |
| Resource assessment, mapping,  | • Measurement programs and model development to assess and map the wind resource  
• Remote sensing programs and techniques  
• Wind atlas development  
• Forecasting techniques  
• Implementation of predictions for wind energy generation | Task 32 LIDAR: Wind lidar systems for wind energy deployment;  
Task 11 Base Technology Information Exchange: Topical Expert Meeting on forecasting techniques.                                                                 |
| Operations and Maintenance      | Condition-based monitoring.                                                                 |                                                                                                                                                                                                                           |
| Environmental issues            | • Developing impact assessment procedures  
• Conducting assessments in sensitive areas  
• Monitoring procedures  
• Wildlife impact: birds, bats, aquatic species  
• Sound propagation  
• Impact on radar systems. | Task 34 Environmental Assessment and Monitoring of Wind Energy Projects                                                                                                                                                    |
| Social impacts                  | Developing techniques for assessment and mitigation of negative attitudes toward wind projects to improve permitting and approval processes. | Task 28 Social Acceptance of Wind Energy Projects;  
Task 27 Small Wind Turbine Labels for Consumers                                                                                                                                                                            |
| Cold climate, severe conditions, | • Assessing the effects of cold on production  
• Mitigating ice formation;  
• Assessing risks of ice fall;  
• Design for lightning, turbulence, and high winds | Task 19 Wind Energy in Cold Climates;  
Task 11 Base Technology Information Exchange: Topical Expert Meeting on wind energy in complex terrain                                                                                                               |
| Building domestic industry      | Support for domestic turbine or component developers to optimize, manufacture, and develop supply chain. |                                                                                                                                                                                                                           |
| Test centers                    | Increase or enhance public/private test centers for design and endurance testing of wind turbines and components including blades, gearboxes, control systems, and wake effects. | Task 29 Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models  
Task 35 Full-Size, Ground-Testing for Wind Turbines and their Components                                                                                                                                                   |
the Impacts of Offshore Wind Turbines on the Marine Environment (StUK4) was presented as an update and published.

In Italy, several joint studies were published that define guidelines for the design of offshore wind parks; assess the more promising solutions for floating platform design; and design an advanced system for floating platform stability.

In Spain, several major research projects completed the work of four years in 2013. The Azimut project concluded applied research on the development of world's largest capacity wind turbine by 2020. Eleven Spanish companies and 22 research centers, coordinated by Gamesa, identified new materials, such as a resin with improved properties for the manufacture of blades and a blade coating with anti-icing properties and high resistance to erosion. They identified technologies to detect the advancing front of resin flow in molds and developed key design and calculation tools for improving generator, blade, and gearbox designs.

The Ocean Leader project, carried out by a consortium consisting of 20 companies and 25 research centers in Spain, set up a smart system capable of placing offshore installations in the most suitable locations. It used three tools to analyze and assess marine resources: the Wave Rider buoy to measure wave motion; the Floatante tower to measure waves; and the Awac to measure currents. It designed new marine technologies including a system of floating wind turbines for deep water and a new turbine for generating energy from currents. It designed a semi-submersible floating substation with specially adapted connectors and dynamic power lines. The project also created a ship that enables this infrastructure to be installed and an operating system managed from a control center designed especially for this type of energy infrastructure.

In Switzerland, research projects about social acceptance of wind plants focused on local acceptance during planning and during operation of the plant. The work shows that acceptance was higher during the operational phase than during the planning phase.

In the United Kingdom, the Offshore Renewable Energy (ORE) Catapult completed pilot projects on industry standardization, offshore cables, and performance and reliability. Under work of the Energy Technologies Institute, the design phase was completed in 2013 of the Very Long Blades Project and a prototype 80-m long blade will be assembled and tested in 2014. Another project completed in 2013 developed an intelligent, integrated, predictive package, which has shown improvements in the capability to holistically monitor wind turbines.

The United States published studies on the nation’s offshore manufacturing and supply chain, manufacturing capability for next-generation drive trains, transportation and logistics for large wind turbines, integration with the electric power system, mitigating radar interference, and impacts on property values.

4.2 Collaborative research
The collaborative research conducted by organizations in the IEA Wind member countries made significant progress in 2013. A key report was published, Recommended Practice 16: Wind Integration Studies, that will help guide the conduct of these important studies assessing the impact of wind power on the power system. In addition, Recommended Practices are under development in Task 27 Small Wind Turbines in High Turbulence and Task 33 Standardizing Data Collection for Wind Turbine Reliability Studies.

Task 11 Base Technology Information Exchange held two Topical Expert Meetings: Forecasting Techniques and Wind Energy in Complex Terrain. Proceedings from these meetings of invited experts are posted in the IEA Wind website. For 2014, four high priority topics were selected for Topical Expert Meetings: Floating offshore wind plants, Meso-scale to micro-scale model coupling, Field test instrumentation and measurement best practices, and Best practices for wind turbine and plant end of life. In 2013, Task 11 also managed the approval process for the new Recommended Practice from IEA Wind Task 25 on the conduct of wind integration studies. IEA Wind Recommended Practices serve as pre-normative guidelines in advance of formal standards to promote best practices available for wind technology and deployment. They are often used as input to the more lengthy full standards process.

Task 19 Wind Energy in Cold Climates task participants contributed to a landmark 2013 market study of cold climate wind energy. The study used sophisticated analysis and global coverage to conclude that the wind energy market potential in cold climate areas is huge; 20% of all installed capacity in
### Table 17. National R&D Budgets 2010–2013 for Reporting Countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Canada</td>
<td>---</td>
<td>6.00</td>
<td>4.23</td>
<td>3.62</td>
</tr>
<tr>
<td>China</td>
<td>---</td>
<td>---</td>
<td>7.63</td>
<td>6.37</td>
</tr>
<tr>
<td>Denmark</td>
<td>18.00</td>
<td>23.40</td>
<td>7.80</td>
<td>17.51</td>
</tr>
<tr>
<td>Finland</td>
<td>4.00</td>
<td>10.00</td>
<td>2.00</td>
<td>3.50</td>
</tr>
<tr>
<td>Germany</td>
<td>53.00</td>
<td>77.00</td>
<td>93.20</td>
<td>37.30</td>
</tr>
<tr>
<td>Greece</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.30</td>
<td>0.30</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Japan</td>
<td>17.85</td>
<td>31.17</td>
<td>40.14</td>
<td>34.50</td>
</tr>
<tr>
<td>Korea</td>
<td>28.36</td>
<td>29.10</td>
<td>33.91</td>
<td>35.60</td>
</tr>
<tr>
<td>México</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Netherlands</td>
<td>38.00</td>
<td>7.08</td>
<td>8.1</td>
<td>5.07</td>
</tr>
<tr>
<td>Norway</td>
<td>12.60</td>
<td>14.87</td>
<td>17.14</td>
<td>13.2</td>
</tr>
<tr>
<td>Portugal</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Spain</td>
<td>150.00</td>
<td>150.00</td>
<td>120.00</td>
<td>85.50</td>
</tr>
<tr>
<td>Sweden</td>
<td>10.80</td>
<td>10.80</td>
<td>10.80</td>
<td>10.80</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>United States</td>
<td>59.52</td>
<td>59.52</td>
<td>70.9</td>
<td>68.20</td>
</tr>
</tbody>
</table>

* Applicable conversion rate EUR to USD: 1.378 (2013)
** Please refer to country chapters for explanations
--- = No data available

### Updated Information

The world is installed in areas classified as cold climates, experiencing either icing or low temperatures or both. In 2014, participants will update the Recommended Practices on wind energy in cold climates published in 2012. Key topics will be site classification, methods for energy yield estimation, harmonizing health and safety recommendations with respect to icing conditions.

Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power participants drafted Recommended Practice 16: Wind Integration Studies that were approved in 2013. This is the first publication aiming to capture current best practice when estimating impacts of wind power on power systems. A summary report was also published highlighting results from 13 national case studies of integration. These case studies address impacts related to incremental increases in reserve requirements, balancing the power system on different short-term time scales: grid congestion, reinforcement, and stability, as well as power adequacy (i.e., capacity value of wind).

Task 26 Cost of Wind Energy continued work to identify elements associated with quantifying the value of wind energy and assess data and methodologies for estimating the cost of wind energy on land. Updated cost of energy estimates on land for participating countries will be produced in 2014.

Task 27 Development and Deployment of Small Wind Turbine Labels for Consumers drafted the IEA Wind Recommended Practice 12 Consumer Label for Small Wind Turbines (2011). This document has been included as an appendix to the IEC TC 88 standard on wind system testing. The task also created the “Small Wind Association of Testers” (SWAT) an international peer network of small wind test experts. The topic and future of labelling will be undertaken by the IEC TC88 Certification Advisory Council Small Wind Turbine subcommittee that now has purview over the important labelling task.

Task 27 Small Wind Turbines at Turbulent Sites is an extension of the original Task 27 to conduct research to improve the IEC standards applying to small wind turbines. Work is under way to gain a better understanding of the special, turbulent wind conditions found in areas of complex terrain such as urban environments and develop potential changes to small wind turbine design per IEC 61400-2. Changes in power performance for small wind turbines in highly turbulent sites will be noted. This work will produce a Recommended Practice on micro-siting of small turbines at turbulent sites.

Task 28 Social Acceptance of Wind Energy Projects is translating the findings of social scientists into the language of planners and engineers to improve the process of bringing wind energy projects to completion. In 2012, participants developed, and IEA Wind approved, Recommended Practice 14 Social Acceptance of Wind Energy Projects to guide good practices by developers and local authorities. In 2013 through 2015 participants will address how to measure and monitor social acceptance.

Task 29 MEXICO II: Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models is working with field and wind tunnel data sets to improve aerodynamic models used to design wind turbines. An inventory of unexplored experiments has been assembled. Calculations in comparison with the measurements were performed for four cases in axial flow of the NREL Phase VI (NASA-Ames) experiment. The results will be published in 2014. The test plan for a new wind tunnel experiment using the MEXICO scale model turbine was designed; the new MEXICO experiment will be conducted in 2014.

Task 30 Offshore Code Comparison Collaboration Continuation (OCCA) is coordinating the work of 15 countries and 61 organizations to improve the design of offshore wind turbines using verified and improved codes. Analysis of a wind turbine
on an offshore floating semisubmersible was completed and several papers were presented. A final report is in preparation. To advance the quality of the models, Task 30 was extended for an additional four years as the Offshore Code Comparison Collaboration Continuation, with Correlation (OC5) project.

Task 31 Wakebench: Benchmarking Wind Farm Flow Models manages the work of 13 countries and 30 organizations to improve atmospheric boundary layer and wind turbine wake models by developing and defining quality-check procedures. In 2013, six active benchmarks were conducted and a standardized fit-to-purpose metric to evaluate models was developed based on the variables of interest for the wind turbine siting process. This will be integrated in Windbench, the web platform that is evolving to accommodate this protocol by implementing online tools for visualizing and quantifying model performance.

Task 32 LIDAR: Wind Lidar Systems for Wind Energy Deployment provides an international information exchange on lidar technology. In 2012, participants and an extended group of experts developed Recommended Practice 15 Ground-Based, Vertically-Profiling Remote Sensing for Wind Resource Assessment. IEA Wind Task 32 will refine this document based on results of the task work into a second edition and provide input to IEC standards development.

Task 33 Reliability Data: Standardization of Data Collection for Wind Turbine Reliability and Operation & Maintenance Analyses will apply the experience of reliability analyses and failure statistics to determine common terminologies, prepare formats and guidelines for data collection, and set up procedures for analysis and reporting. Internal reports have been assembled from the survey of 28 initiatives collecting reliability data. These and two other state-of-the-art reports from working groups will supply the foundation for developing Recommended Practices for Reliability Data.

Task 34 Environmental Assessment and Monitoring of Wind Energy Projects on Land and Offshore was approved in 2012 to share information from completed and on-going environmental assessment and monitoring efforts on land and offshore, both pre- and post-construction. A survey of participants was used to refine the work plan in 2013.

An important new IEA wind research task began work in 2013, Task 35 Full-Size Ground Testing of Wind Turbines and their Components (blades and drive trains). Ground-based testing is a less costly alternative to full-scale field testing of prototype wind turbines. Ground-based test benches offer the opportunity to evaluate wind turbine components under repeatable, accelerated life conditions and are an important tool for development and certification of new wind turbines. Task 35 is gathering the key stakeholders in the wind industry together to discuss consistency in the development and use of system test benches for wind turbines and their components. During the startup phase, a blade test group and a nacelle assembly test group has been set up.

The International Energy Agency approved the extension request of IEA Wind and work will continue through 2019 following the strategic plan.

After assessing the accomplishments of the previous five years and developing a new strategic plan the members concluded that significant cost reductions are possible with R&D in the strategic areas of wind characteristics, wind power technology, wind integration, and social, environmental and educational issues.

5.0 The Next Term
Increasing performance of the world’s wind generation fleet will continue to expand its role in the electricity generation portfolio. Wind turbines with towers, blades, and generators designed for specific locations will incorporate the latest technology to extract the greatest amount of energy from the wind. On land, improved technology will allow expanded, cost-effective installation of wind turbines in forested and otherwise complex terrain. Offshore wind applications will greatly expand the generation capacity of many nations.

Expanding membership in IEA Wind will enhance the benefits of co-operation. At press, France became a new member and invitations to Belgium and Israel are expected to be accepted in 2014. All countries with active interest in wind energy are welcome to explore participation by contacting the Chair or Secretary by email at ieawind@comcast.net.

References and notes:
Opening photo: The Hall of Supreme Harmony; Forbidden City, Beijing, China (ExCo 72 was held in Beijing in 2013) (Credit: Rick Hinrichs, PWT Communications LLC)
Statistics for IEA Wind member countries have been provided by the authors of the country chapters and represent the best estimates of their sources in March 2013. For the latest information, visit www.ieawind.org.

Author: Patricia Weis-Taylor, Secretary, IEA Wind.