World wind energy development*

• Market growth has averaged 21% over the past 10 years.
• In 2013, the market grew 12.5% vs. nearly 19% growth in 2012.
• 35 GW of new capacity were installed in 2013 ending with 318 GW of wind power globally.

Wind energy development brings national benefits

- Worldwide, new wind energy installations in 2013 represented an investment of 59 billion EUR (80 billion USD).*
- More than 834,000 people were employed in the global wind industry in 2013.**

Sources: *GWEC 2013; **Irena 2013; EWEA 2013
Wind energy is part of the global economy

• Worldwide, new wind energy installations in 2013 represented an investment of 59 billion EUR (80 billion USD).*

• More than 834,000 people were employed in the global wind industry in 2013.**

• In Europe, wind power accounted for 32% of total 2013 power capacity installations.

Sources: *GWEC 2013; **Irena 2013; EWEA 2013
Wind energy is changing the electric generation mix

In 2013, new global wind power capacity (35 GW) at plants such as this one in the United Kingdom equaled the capacity of 17.5 coal power plants, like the 2-GW Cottam Power Station in the United Kingdom.
85% of the world wind capacity is in IEA Wind member countries.
IEA Wind has broad membership*

OECD Participating Countries and International Organisations:

Europe:
Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the European Commission, and the European Wind Energy Association

North America:
Canada, México, and the United States

Asia and Pacific:
Chinese Wind Energy Association, Japan, and South Korea

* Membership is open to all countries interested in developing wind energy.
Wind generation is significant and growing in IEA Wind member countries.
IEA Wind participants added nearly 30 GW of wind generation in 2013.

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity Added (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>16,089</td>
</tr>
<tr>
<td>Germany</td>
<td>3,356</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2,422</td>
</tr>
<tr>
<td>Canada</td>
<td>1,599</td>
</tr>
<tr>
<td>United States</td>
<td>1,087</td>
</tr>
<tr>
<td>Sweden</td>
<td>862</td>
</tr>
</tbody>
</table>

Capacity added in 2013 (MW)
Source: IEA Wind 2013 Annual Report
## Wind contributes to national electrical demand

<table>
<thead>
<tr>
<th>IEA Wind Member Country</th>
<th>National electricity demand</th>
<th>National electricity demand from wind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TWh/yr</td>
<td>%</td>
</tr>
<tr>
<td>Denmark</td>
<td>34</td>
<td>32.7%</td>
</tr>
<tr>
<td>Spain</td>
<td>261</td>
<td>26.9%</td>
</tr>
<tr>
<td>Portugal</td>
<td>51</td>
<td>23.5%</td>
</tr>
<tr>
<td>Ireland</td>
<td>28</td>
<td>16.3%</td>
</tr>
<tr>
<td>Germany</td>
<td>600</td>
<td>8.9%</td>
</tr>
<tr>
<td>Sweden</td>
<td>139</td>
<td>7.0%</td>
</tr>
<tr>
<td>UK</td>
<td>376</td>
<td>6.0%</td>
</tr>
<tr>
<td>Austria</td>
<td>62</td>
<td>5.8%</td>
</tr>
<tr>
<td>Greece</td>
<td>57</td>
<td>5.8%</td>
</tr>
<tr>
<td>Italy</td>
<td>317</td>
<td>4.7%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>120</td>
<td>4.7%</td>
</tr>
<tr>
<td>Australia</td>
<td>226</td>
<td>4.1%</td>
</tr>
<tr>
<td>United States</td>
<td>4,058</td>
<td>4.1%</td>
</tr>
<tr>
<td>Canada</td>
<td>560</td>
<td>3.1%</td>
</tr>
<tr>
<td>China</td>
<td>5,245</td>
<td>2.6%</td>
</tr>
<tr>
<td>México</td>
<td>249</td>
<td>1.5%</td>
</tr>
<tr>
<td>Norway</td>
<td>129</td>
<td>1.5%</td>
</tr>
<tr>
<td>Finland</td>
<td>84</td>
<td>0.9%</td>
</tr>
<tr>
<td>Japan</td>
<td>846</td>
<td>0.5%</td>
</tr>
<tr>
<td>Korea</td>
<td>532</td>
<td>0.2%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>64</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

* % of national electricity demand from wind = (wind generated electricity / national electricity demand)

Source: IEA Wind 2013 Annual Report
Wind energy development brings national benefits

The U.S. wind fleet generated almost 168 TWh of electricity in 2013, which avoided nearly 96 million tons of carbon dioxide (CO₂) emissions from power generation.

<table>
<thead>
<tr>
<th>IEA Wind Country</th>
<th>Total Wind Capacity (MW)</th>
<th>Estimated jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>91,413</td>
<td>360,000</td>
</tr>
<tr>
<td>U.S.</td>
<td>61,110</td>
<td>50,500</td>
</tr>
<tr>
<td>Germany</td>
<td>34,660</td>
<td>100,000</td>
</tr>
<tr>
<td>Spain</td>
<td>22,959</td>
<td>20,000</td>
</tr>
<tr>
<td>U.K.</td>
<td>10,861</td>
<td>16,500</td>
</tr>
<tr>
<td>Italy</td>
<td>8,554</td>
<td>30,000</td>
</tr>
<tr>
<td>Denmark</td>
<td>4,808</td>
<td>23,000</td>
</tr>
</tbody>
</table>

Source: IEA Wind 2013 Annual Report
IEA Wind supports national efforts with information exchange and joint R&D

• Sharing information on:
  – Planning and execution of large-scale wind energy deployment
  – Experiences with tariffs, credits, certificates and other incentive and regulatory environments
  – Results of national technology research projects

• Cooperative research tasks performed with research and in some countries industry experts.
IEA Wind Strategic Direction 2014-2019

- Reduce the cost of wind energy use, for both land-based and offshore wind
- Increase the flexibility of transmission and power systems
- Increase social acceptance and environmental compatibility of wind energy
- Increase the exchange of best practices
Information Dissemination

- Annual Reports (1,200 copies/yr)
- Website
- Technical reports, journal articles, conference presentations
- Outreach to new members
- Industry Encounters
- Recommended Practices
- E-newsletter
IEA Wind R&D continues to reduce costs

- Grid integration tools
- Designs to increase performance/value
  - Forecasting
  - Aerodynamics
  - Structural dynamics
  - Electrical systems
- Designs for specific locations
  - Cold climate
  - Offshore
  - High wind/turbulence
- Impact assessment
  - Cost assessment tools
  - Social impacts
  - Environmental impacts
IEA Wind Joint R&D Tasks: multiplying national research efforts

• Task 25 Power Systems With Large Amounts of Wind Power (First term)
  – Contribution per participant: 7 002 Euro plus in-kind effort over 3 years
  – Total value of shared labor: 9 528 000 Euro

• Task 24 Integration of Wind and Hydropower Systems
  – Contribution per participant: 16 430 USD plus in-kind effort over 3 years
  – Total value of shared labor: 6 237 000 USD

• Task 23 Offshore Wind Technology and Deployment
  – Contribution per participant: 18 675 USD plus in-kind effort over 5 years
  – Total value of shared labor: 4 630 000 USD (Subtask 2)
Active Research Tasks of IEA Wind

Full-Size Ground Testing of Wind Turbines and Components (Task 35)
Environmental Assessment and Monitoring for Wind Energy Systems (Task 34)
Reliability Data: Standardizing Data Collection for Wind Turbine Reliability, Operation and Maintenance Analyses (Task 33)

Lidar: Wind lidar systems for wind energy deployment (Task 32)
WAKEBENCH: Benchmarking wind farm flow models (Task 31)
Dynamic Codes and Models for Offshore Wind Energy (Task 30)
Aerodynamic Data Analysis of the EU MEXICO Project (Task 29)
Social Acceptance of Wind Energy Projects (Task 28)
Consumer Labeling of Small Wind Turbines (Task 27)
Cost of Wind Energy (Task 26)
Power Systems with Large Amounts of Wind Power (Task 25)
Wind Energy in Cold Climates (Task 19)
Base Technology Information Exchange (Task 11)
Active Research Tasks of IEA Wind

• Each task is managed by an Operating Agent (OA) organization with a designated expert managing the work.
• Participants develop a work plan and agree to contribute to the work plan.
• Participants agree to pay the budgeted fees for the Operating Agent (if applicable).
• For detailed information about each task, including contact information and the work plan, visit www.ieawind.org and click on the Task website link at the left of the home page.
Task 11 Topical Experts Meetings: exclusively for experts from participating member countries (recent topics explored)

- Advances in testing wind turbines and components (28 experts from 7 countries).
- Social acceptance of wind energy projects (19 experts from 8 countries).
- Wind farm control methods (18 experts from 6 countries).
- Wind farms in complex terrain (28 experts from 8 countries).
- Forecasting techniques (23 experts from 10 countries)
Task 19 addresses cold climate issues for wind energy

- Developed Recommended Practice for wind energy projects in cold climates
- Conducted a market survey for cold climate technology
- Explores technologies to increase productivity
- Develops tools to predict performance
Design and operation of power systems with large amounts of wind power – Task 25

• International forum for wind integration, actively following also parallel activities (CIGRE, UWIG, IEEE, other IEA IAs).

• Analysing and further developing the methodology to assess the impact of wind power → best practices to assess the impacts

• Summaries on the range of impacts, evolving experience as well as integration solutions
• GOAL: understand cost of wind energy among participating countries
  • Identified cost elements from the perspective of a private investor, in a given project, in each country
  • Calculated levelized cost of energy (LCOE) - the sum of all costs over project lifetime, discounted to present, and levelized based on annual production
• Used two approaches: 1. high level scenario planning and 2. sophisticated financial cash flow analysis
• Results:
  • LCOE varies considerably between countries
  • Variation is attributed to energy production, investment cost, operations cost, and financing cost
Small wind turbines: labels for consumers and designing for turbulent sites

• Develop approved test procedures and consumer label for small wind turbines

• Set up Small Wind Association of Testers (SWAT)
  – Encourage peer review of test protocols and data analysis
  – Promote dissemination of results
Social Acceptance of Wind Energy Projects, Task 28

• State-of-the-Art Report compiled current knowledge about social acceptance of wind energy projects.
• Strategies to resolve social acceptance challenges, include:
  • Engage and seek public consultation early
  • Employ participatory development and investment models
  • Implement coordinated and efficient processes
  • Continue refining and communicating state-of-the-art knowledge
Aerodynamic Research, Task 29

- MexNEXT analyses wind tunnel measurements and improves aerodynamic models
  - Using measurements of a wind turbine in the large German Dutch Wind Tunnel, DNW
  - Measurements are available from EU-funded project *Measurements and Experiments in Controlled Conditions, MEXICO*
Comparing Structural Models for Offshore Wind Development, OC5 Task 30

• Technical research for deeper water
  – Benchmarks structural dynamics models for estimating offshore dynamic loads
  – Identifies and verifies model capabilities and limitations
Benchmark Wind Farm Flow Models, Task 31

- Improves wind farm wake modeling techniques
- Provides a forum for industry, government, and academic partners
- Develops, evaluates, and improves atmospheric boundary layer and wind turbine wake models for use in wind energy.
Lidar: Wind Lidar Systems for Wind Energy Deployment, Task 32

- Exchange experience from research activities and measurement projects on the performance of lidar devices and associated measurement techniques
- Continue the development of an “IEA Recommended Practices for Remote Sensing Measurements“ (Action 59th Topical Expert meeting) and refine it during the course of the task in the three areas:
  a) measurement techniques
  b) resource assessment
  c) power curve measurements and load estimation
- Identify areas for further research and development as well as standardization needs.
Reliability Data: Standardizing data collection for wind turbine reliability and maintenance analyses, Task 33

- Provide an open forum on failure and maintenance statistics on wind turbines for exchange of experience from individual research projects
- Develop an IEA Wind recommended practice for collecting and reporting reliability data
- Identify research, development, and standardization needs for collecting and reporting reliability data.
Environmental Assessment and Monitoring of Wind Energy Projects, Task 34
WREN – Working together to resolve environmental effects of wind energy

- Share information from completed and ongoing environmental assessment and monitoring efforts onshore and offshore, pre- and post-construction
- Improve monitoring approaches
- Make data easily accessible to all interested parties
- Aggregate information on biological species affected
- Aggregate information on effects of mitigation strategies
- Identify successful approaches to monitoring impacts, analysis techniques, and assessment methodologies.
Full Size Ground Testing for Wind Turbines and Their Components, Task 35

- Guide the use of test facilities for wind turbine components (blades and drivetrains) as an alternative or complement to on-tower field tests
- Develop recommended practices for
  - requirements and boundary conditions of test rig configurations
  - uniform test procedures and measurements
  - Requirements for interfaces and subsystems for realistic investigations of drivetrain and component test rigs.
  - proposals for uniform and qualitative analysis of test results for wind turbines components.
For more information, visit www.ieawind.org or email the Secretary ieawind@comcast.net.
IEA Wind contacts

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Vice Chair – John McCann, Ireland
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Vice Chair – Brian Smith, United States
  (brian.smith@nrel.gov)

Secretary – Patricia Weis-Taylor, United States
  (ieawind@comcast.net)
References


• Global Wind Energy Council (GWEC), February 2013

• IEA Wind task reports posted to www.ieawind.org
IEA Disclaimer

The IEA Wind agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.
Mission of IEA Wind

“...to stimulate co-operation on wind energy research and development and to provide high quality information and analysis to member governments and commercial sector leaders by addressing technology development and deployment and its benefits, markets, and policy instruments.” – IEA Wind Strategic Plan
IEA Wind organisational details

• IEA Wind is one of the more than 40 Implementing Agreements under International Energy Agency (IEA) Organization for Economic Co-operation and Development (OECD). It is attached to the Renewable Energy Working Party (REWP).

• The full, legal name of the activity is the IEA Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems.

• Benefits include:
  – Guide national governmental programmes and policies through information exchange
  – Develop skills, knowledge and improve wind R&D cost effectiveness and minimise environmental effects
  – Provide information and technology to reduce costs and increase the value of wind energy
  – Identify and publicise societal, economical and governmental benefits
IEA Wind operational details (1)

- The IEA Wind Executive Committee (ExCo) organises the overall information exchange and the R,D&D tasks

- The ExCo consists of a Member and an Alternate Member from each contracting party in the Implementing Agreement

- Most countries are represented by one contracting party such as a government department or agency

- The ExCo meets twice a year to discuss the R&D programs of the member countries, to report work progress on the various Tasks, and to plan future activities
IEA Wind operational details (2)

- Most decisions are reached by majority vote with one vote per member country. Change to members rights and contractual obligations require unanimity.

- Members share the cost of administration for the ExCo through annual contributions (based on the size of the nation’s economy) to a Common Fund.

- Each research task has its own budget and fees based on the work and number of participants.

- Each member country must participate in at least one research task.