OVERVIEW

China continues to have the highest wind power capacity in the world, although the pace of growth slowed in 2017. 19,659 MW of new wind power capacity was installed, representing a 15.9% decrease in growth from last year. Accumulated capacity increased to 188,390 MW.

Grid-connected capacity increased to 164,000 MW with the addition of 15,030 MW installed in 2017. New wind power capacity accounted for 9.2% of installed power capacity nationwide. New installations in the mid-eastern and southern regions account for 50% of the total new installation capacity.

Wind power remains the third largest generation source in China, following thermal and hydro-electricity sources. The average full-load-hour of wind power was 1,948 hours in 2017, an increase of 203 hours from 2016. Wind-generated electricity totaled 305.7 TWh, increase 26.3% over the previous year. Wind-generated electricity accounted for 4.8% of the total electricity generation, an increase of 0.7% over 2016. The average wind curtailment rate was 12%, a decline of 3% compared to 2016.

In 2017, the Chinese government issued a series of policies and regulations to reduce wind curtailment and promote the development of distributed wind power. In addition, Chinese companies made progress in R&D, including wind energy developments in low wind-speed areas and offshore wind energy generation.

MARKET DEVELOPMENT

National Targets & Policies Supporting Development

In 2016, the Chinese government released the 13th Five-Year Plan on Renewable Energy Development (2016-2020). This plan set several targets to promote the energy transition in China. By the end of 2020, installed wind power capacity will grow to more than 210 GW, and installed offshore wind power capacity will total approximately 5 GW.

In 2017, the National Energy Administration (NEA) issued guidelines on implementation of the 13th Five-Year Plan. These guidelines included measures promoting assumption, reducing cost, and more to ensure the completion of the five-year plan. In addition, the guidelines updated wind energy construction targets for the provinces from 2017 to 2020. According to the plan, new installations will reach 110 GW—significantly more than the previous five-year plan target of 79 GW. Henan and Hebei will be the fastest growing provinces, with the new installation of 12 and 11 GW.

Hebei, Shandong, Jiangsu, Shanghai, Guangdong and others also set offshore wind development targets for this five-year plan period. In Jiangsu and Guangdong provinces, installed offshore wind power will reach 3.5 GW and 2 GW, respectively.

The NEA also issued an implementation plan, which set targets for reducing curtailment of wind, solar, and hydropower power generation. The plan presented some concrete measures, such as: improving the management mechanism of target assessment; promoting renewable energy power market transactions; implementing renewable energy electricity quotas; and enhancing power transmission capacity. Under this plan, the problem of wasted renewable energy will be solved by 2020.

In 2017, the NEA issued requirements aimed at speeding the construction of distributed wind power projects. It presented rules for distributed wind power development
and encouraged the government’s department of energy to simplify project approval procedures. Distributed wind power project construction will not be restricted by the annual limit for new installations.

In 2017, the National Development and Reform Commission (NDRC), Ministry of Finance, and NEA implemented a voluntary subscription trading system for renewable energy certificates (RECs). The REC system will stimulate renewable energy consumption by creating a new subsidy mechanism for renewable energy development in China.

**Progress & Operational Details**

By the end of 2017, China installed 19,659 MW of new wind power capacity (exclusive of Taiwan). This accounted for 37% of new global wind capacity for the year. The accumulated wind power capacity in China reached 188,390 MW, accounting for 34.9% of wind power capacity worldwide, maintaining the highest wind power capacity in the world.

Compared to 2016, the rate of new wind-power installations decreased by 15.9%, although cumulative installed power capacity increased by 11.6%. Wind power generation reached 306 TWh in 2017—4.8% of total electricity generation.

A total of 9,310 new wind turbines were installed in 2017, bringing the national total of operating turbines to 114,244. The average capacity of newly installed wind turbines was about 2.1 MW, an increase of 7.3% since 2016. The average capacity of all installed wind turbines increased to 1.7 MW.

The five provinces with the most new installed capacity were:
- Hebei (2.1 GW)
- Shandong (1.5 GW)
- Jiangsu (1.5 GW)
- Inner Mongolia (1.4 GW)
- Qinghai (1.3 GW)

Together, these accounted for 40% of the new capacity nationwide. The middle, eastern, and southern regions of China account for 50% of new installations. The average weighted full load hours of operating wind farms totaled 1,948 hours, an increase of 203 hours as compared to 2016.

Factors that influence cost of wind energy include levels of wind resources, construction conditions, mainstream wind turbine technologies, and wind farm operation levels.

With current technology, and without considering the cost of long-distance transmission or the environmental and resource benefits of wind power, the cost of wind power is higher than that of coal-fired power. If resources and environmental benefits are taken into consideration, the cost of wind power is nearly equal to that of coal-fired power generation.

**Matters Affecting Growth & Work to Remove Barriers**

Integration and consumption are still significant problems limiting wind power development in China. Wind curtailment continues to be the main restriction on wind power development.

The annual curtailed wind-generated electricity is 42 TWh. Gansu (33%), Xinjiang (29%), Jilin (21%), and Inner Mongolia (15%) are the four provinces with the highest wind curtailment rates in China. The government took some measures in 2017 to resolve this problem, including increasing peak regulation capacity and encouraging inter-provincial compensation. Consequently, the wind curtailment rate reduced 15.7% since 2016.

Because feed-in tariffs can increase the financial burden and the resulting deficit can sap the motivation of wind power developers, work to perfect market mechanisms is one of the most important measures. In 2017, the REC system began to be implemented; this system allows wind power producers to get extra income from the voluntary trade of RECs, which can cover these losses. Also, the corresponding feed-in tariff from government will be removed.

The higher power price made it harder for wind power to compete with coal-fired generation. To drive cost reduction of wind power and increase market competitiveness, the NEA carried out wind-power parity demonstration work.

In 2017, 13 projects were selected to verify the availability of the same transaction price as coal-fired generation. These projects were distributed throughout Hebei, Gansu, Xinjiang, Heilongjiang, and Ningxia provinces in China’s “Three North” areas (northwest China, north China, and northeast China).
**National R,D&D Priorities & Budget**

In 2017, the Ministry of Science and Technology of the People’s Republic of China launched the National Quality Infrastructure (NQI) Research Program. The program, which includes 76 tasks, began implementation in 2017 and aims to improve the innovation capability of NQI in China. The total budget is above 700 million CNY (89.7 million EUR; 107.6 million USD), and the budget for renewable energy is above 10 million CNY (1.3 million EUR; 1.5 million USD). Two research projects are related to wind power:

- **Testing, monitoring, and evaluation technology of key renewable energy equipment in service**, including detective techniques without disassembly for key mechanical parts of wind turbines; early damage and operation condition monitoring technologies; and key battery storage technologies.

- **Quality evaluation technologies for renewable energy and related products**, including reliability design and evaluation of wind turbines. This project explores quality evaluation technology for the whole production process of key components of wind turbines, and evaluations of performance, operational reliability, and residual life of wind turbines.

The expected results of this project include:

- New testing and monitoring methods and devices for wind energy and photovoltaic power generation equipment
- A diagnostic system for wind turbine blade defects
- A data analysis system for wind turbine operations
- Set standards on the reliability index and computing methods
- Set standards for methods of evaluating the power generation performance of wind turbines
- Set standards for manufacturing process quality evaluation of wind turbine blades, gearboxes and generators
- An operating condition analysis and intelligent diagnostic system for photovoltaic power generation systems
- An evaluation database for the sustainable development of biomass energy production.

In 2017, the budget of the NQI Project for renewable energy was about 3 million CNY (0.4 million EUR; 0.5 million USD). In 2018, most will support the Key Program of the research on renewable energy and hydrogen energy, including six research directions of: solar energy; wind energy; biomass energy; geothermal and ocean energy; hydrogen energy; and renewable energy coupling and system integration technology.

**National Research Initiatives & Results**

Ice formation on wind turbine blades is a worldwide problem. Icing on turbine blades not only imperils the safety of the wind turbine itself, it also reduces power generation capacity. Goldwind resolved this problem by developing a new de-icing system, which includes an anti-icing coating, an icing security protection mode, and a blade heating system. This system should greatly increase wind power generation.

Information technology has monitored and controlled systems of wind turbines as well as manage wind farms. In 2017, many Chinese wind turbine manufacturers (e.g., Envision, Goldwind, Mingyang, etc.) launched new wind turbine monitoring and controlling systems. The new systems include more powerful functions, such as increasing power generation through precise control and supporting operation and maintenance through intelligent diagnosis and management.

To enhance the manufacturing efficiency and quality of wind turbines, some domestic manufacturers have begun to develop intelligent production lines. By using the technology of robotics, big data, and the “Internet of Things”, wind turbines and components can be assembled automatically, and the management of the manufacturing process will become more efficient.
Test Facilities & Demonstration Projects
To improve development in low wind-speed areas, research on new wind turbine towers has drawn the attention of many manufacturers. In 2017, Envision, a famous wind turbine manufacturer in China, finished the construction of the highest wind turbine tower with a height of 140 m in Henan province.

The blade is the key wind turbine component for converting wind energy into mechanical energy. The length and quality of the blade determine whether the wind turbine can enhance production capacity and obtain a high power coefficient. Chinese blade manufacturers are striving to design longer and higher-quality blades. In 2017, SUNRUI, a domestic blade manufacturer, produced the longest turbine blade of 83.6 m.

The China General Certification Center, the predominant certification and testing body in China, finished the natural frequencies and static tests of the longest blade (83.6 m) in 2017 (Figure 2). This work showcases the advanced technical abilities of China’s testing entity.

Collaborative Research
By the end of 2017, the CWEA had arranged for 28 domestic wind power companies, research institutes, and universities to attend IEA Wind TCP Tasks:

- Task 11 Base Technology Information Exchange
- Task 19 Wind Energy in Cold Climates
- Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power
- Task 27 Small Wind Turbines in High Turbulence Sites
- Task 29 Mexnext: Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models
- Task 30 Offshore Code Comparison, Collaboration, Continued, with Correlation (OCS)
- Task 31 Benchmarking of Wind Farm Flow Models
- Task 32 Lidar Systems for Wind Energy Deployment
- Task 35 Full-Size Ground Testing for Wind Turbines and Their Components
- Task 36 Forecasting for Wind Energy
- Task 37 Systems Engineering
- Task 39 Quiet Wind Turbine Technologies

Wind power results in China include: a study on breakup and impingement characteristics of super cooled large droplets (Figure 3); the numerical simulation of turbulence characteristics and wind power output on a roof under different flow conditions; a comparative study of the aerodynamic performance of the New Mexico Rotor in yaw conditions (Figure 4); a dynamic calculation program and model comparisons of offshore wind energy; a study of large-scale wake flow field characteristics (Figure 5); optimization of wind turbine reliability data and evaluation index; a study on wind plant coding and revision of the relevant national standard.

Figure 4. Comparisons of axial velocity distributions regarding nacelle effect

Figure 5. a) Wind velocity profile at different downstream position of the wind turbines; b) Wind velocity distribution, at x=3D, on Y-Z plane; c) Wind velocity distribution, on X-Y plane
Impacts of Wind Energy

Environmental Impact
According to the 13th Five-Year Plan, wind-generated electricity will reach 420 billion kWh, or 6% of the total electricity. This is very important for realizing the 15% target for non-fossil fuel energy in primary energy consumption. In 2017, wind-generated electricity totaled 305.7 billion kWh, which saved about 109 million tons of standard coal per year, and reduced 277 million tons of CO₂, 0.8 million tons of SO₂, and 0.95 million tons of NOₓ. Based on wind-generated electricity predictions for 2020, wind power will save 150 million tons of standard coal per year and reduce 380 million tons of CO₂, 1.3 million tons of SO₂, and 1.1 million tons of NOₓ. It will play an important role in reducing air pollution and controlling greenhouse gas emissions.

Economic Benefits & Industry Development
During the 13th Five-Year Plan period, new installation capacity will reach more than 80 GW, including more than 4 GW of new capacity of offshore wind-power. With land-based wind power investment of 7,800 CNY/kW (998.4 EUR/kW; 1,201 USD/kW) and offshore wind power investment of 16,000 CNY/kW (2,048 EUR/kW; 2,464 USD/kW), the total investment in wind energy during the plan period will reach more than 600 billion CNY (76.8 billion EUR; 92.4 billion USD).

The development of the wind energy industry will markedly enhance the development of related industries and increase employment. During the 13th Five-Year Plan period, about 15 jobs will be produced for every 1 MW of installed wind power capacity, and it is estimated that more than 800,000 people will be employed in the wind power industry by 2020. In 2017, more than 80 developers had new installations in China. The accumulated installed capacity of the top ten developers accounted for 71% of the total installed capacity (Table 2). The top five developers in China accounted for 53.3% of new wind installed capacity and the top ten developers accounted for 58.8% of new wind-power capacity.

Twenty-two manufacturers in China have new wind energy installations. The top manufacturer of new installations was Goldwind (5,230 MW), accounting for 26.6% of new wind installations, which greatly benefited the wind power industry. The top ten manufacturers accounted for 89.5% of the new wind installations in 2017 (Table 3).

In the past five years, market share has gradually concentrated in large companies. In 2017, the top five manufacturers’ market share increased from 54.1% in 2013 to 67.1%, and the top ten manufacturers’ market share increased from 77.8% in 2016 to 89.5%.

In 2017, many wind turbine manufacturers (including Goldwind, Envision, Mingyang, United Power, CSIC Haizhuang, and Shanghai Electric) released new products. Goldwind, Envision, and Mingyang released the 6-MW, 4.5-MW, and 5.5-MW offshore wind turbines, respectively.

Next Term
In 2018, policies on the compulsory quota system and distributed wind power development will be issued in support of the development of the wind energy industry. In addition, new research projects will be carried out to improve product quality and enhance wind farm construction capacities. CWEA will continue to do its best to organize national research efforts and related activities.

References
Opening photo: Wind farm in Jiangsu province (Photo credit: CWEA)
Authors: He Dexin, Du Guangping, and Lyu Bo, Chinese Wind Energy Association (CWEA), China.

Table 2. Top 10 Developers of New Wind Installations During 2017 (Source: CWEA)

<table>
<thead>
<tr>
<th>#</th>
<th>Developer</th>
<th>Capacity (MW)</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China Energy Investment Corporation (China Guodian Corporation and Shenhua Group)</td>
<td>3,768</td>
<td>20.0%</td>
</tr>
<tr>
<td>2</td>
<td>Huaneng Group</td>
<td>1,901</td>
<td>10.1%</td>
</tr>
<tr>
<td>3</td>
<td>Datang Group</td>
<td>1,689</td>
<td>9.0%</td>
</tr>
<tr>
<td>4</td>
<td>SPIC</td>
<td>1,368</td>
<td>7.3%</td>
</tr>
<tr>
<td>5</td>
<td>Huadian Group</td>
<td>1,302</td>
<td>6.9%</td>
</tr>
<tr>
<td>6</td>
<td>CGN</td>
<td>1,175</td>
<td>6.2%</td>
</tr>
<tr>
<td>7</td>
<td>Huaran</td>
<td>668</td>
<td>3.5%</td>
</tr>
<tr>
<td>8</td>
<td>Tianrun</td>
<td>559</td>
<td>3.0%</td>
</tr>
<tr>
<td>9</td>
<td>Power Construction Corporation of China</td>
<td>525</td>
<td>2.8%</td>
</tr>
<tr>
<td>10</td>
<td>China Three Gorges Corporation</td>
<td>423</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>5,461</td>
<td>29.0%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18,839</td>
<td>100.00%</td>
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Table 3. Top 10 Manufacturers of New Wind Installations During 2017 (Source: CWEA)

<table>
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<tr>
<th>#</th>
<th>Manufacturer</th>
<th>Capacity (MW)</th>
<th>Share</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Goldwind</td>
<td>5,230</td>
<td>26.6%</td>
</tr>
<tr>
<td>2</td>
<td>Envision</td>
<td>3,040</td>
<td>15.4%</td>
</tr>
<tr>
<td>3</td>
<td>Mingyang</td>
<td>2,460</td>
<td>12.5%</td>
</tr>
<tr>
<td>4</td>
<td>United Power</td>
<td>1,310</td>
<td>6.7%</td>
</tr>
<tr>
<td>5</td>
<td>CSIC Haizhuang</td>
<td>1,160</td>
<td>5.9%</td>
</tr>
<tr>
<td>6</td>
<td>Shanghai Electric</td>
<td>1,120</td>
<td>5.7%</td>
</tr>
<tr>
<td>7</td>
<td>XEMC-Wind</td>
<td>930</td>
<td>4.7%</td>
</tr>
<tr>
<td>8</td>
<td>Windey</td>
<td>830</td>
<td>4.2%</td>
</tr>
<tr>
<td>9</td>
<td>Dongfang Turbine</td>
<td>800</td>
<td>4.1%</td>
</tr>
<tr>
<td>10</td>
<td>Huachuang</td>
<td>730</td>
<td>3.7%</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2,070</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>19,660</td>
<td>100.00%</td>
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