1.0 Overview

Sweden’s new wind energy installations in 2013 had a capacity of 862 MW, compared to 755 MW installed in 2012. At the end of 2013, the total installed wind generation in Sweden was 4,459 MW from 2,681 wind turbines. The goal is to increase renewable generation by 25 TWh compared to the level in 2002 by 2020. A major part of wind power research financed by the Swedish Energy Agency is carried out in the research programs Vindforsk, Vindval, Swedish Wind Power Technology Center (SWPTC), and wind power in cold climate. Vindforsk focuses on wind resources and establishment, operation and maintenance, and wind power in the power system. Vindval is a knowledge program focused on studying the environmental effects of wind power. SWPTC’s main objective is the design of an optimal wind turbine, which takes the interaction among all components into account. The program wind power in cold climate focuses on removing barriers that arise for wind power in cold climates.

2.0 National Objectives and Progress

In 2008, the Swedish government expressed a planning framework of 30 TWh wind power by 2020, comprised of 20 TWh onshore and 10 TWh offshore. Within the electricity certificate system, the goal is to increase renewable electricity generation by 25 TWh by 2020 compared to the level in 2002. Electricity generation from wind power has increased from 7.1 TWh in 2012 to 9.9 TWh in 2013 (Figure 1).

The Swedish electricity end use in 2013 was 139.0 TWh, a decrease of about 2% compared to 2012. The wind power electricity generation share for 2013 was 9.9%.

2.1 National incentive programs

There are two main incentive programs for the promotion of wind power: electricity certificates and support for technical development in coordination with market introduction for large-scale plants offshore and in arctic areas. The work done in assessing areas of national interest for wind power can also be considered a sort of “soft incentive.”

Electricity Certificates

The electricity certificate system came into force on 1 May 2003, and it is intended to increase the production of renewable electricity in a cost-efficient way. The increased deployment of renewable electricity generation will be driven by stipulated quotas that are increased annually, as well as by a quota obligation fee. The principle is that there should be sellers and purchasers of certificates and a market to bring them together. There are no specific quotas for wind power. Electricity producers receive a certificate from the state for each megawatt hour of renewable electricity that they produce. This certificate can be sold to provide additional revenue above the sale of the electricity, improving the economics of electricity production from renewable energy sources and encouraging the construction of new plants for the purpose.

The demand for certificates is created by a requirement under the Act that all electricity suppliers and certain electricity users purchase certificates equivalent to a certain proportion of their electricity sales or use, known as their quota obligation. The price of certificates is determined by supply and demand, and it can vary from one transaction to another.

Since 1 January 2012, Sweden and Norway have shared a common electricity certificate market. This means that the electricity certificate can take place across borders. The goal of the joint certificate market is to increase renewable electricity by 26.4 TWh between 2012 and 2020. This represents approximately 10% of electricity production in the two countries.

Support for technical development

In 2003, the Swedish Energy Agency launched a program to support technical development, in coordination with market introduction, for large-scale plants offshore and
Electricity generation from wind power in Sweden increased from 7.1 TWh in 2012 to 9.9 TWh in 2013.

Table 1. Key National Statistics 2013: Sweden

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total installed wind capacity</td>
<td>4,469 MW</td>
</tr>
<tr>
<td>New wind capacity installed</td>
<td>862 MW</td>
</tr>
<tr>
<td>Total electrical output from wind</td>
<td>9,912 TWh</td>
</tr>
<tr>
<td>Wind generation as % of national electric demand</td>
<td>9.9%</td>
</tr>
<tr>
<td>Average capacity factor*</td>
<td>28.3%</td>
</tr>
<tr>
<td>Target: Planning framework of 30 TWh wind power by 2020</td>
<td>Bold italic indicates an estimate</td>
</tr>
<tr>
<td>* Estimate based on the average installed capacity during the year.</td>
<td></td>
</tr>
</tbody>
</table>

Electricity generation from wind power in Sweden increased from 7.1 TWh in 2012 to 9.9 TWh in 2013.

Areas of national interest
According to the environmental code, land and water areas shall be used for the purposes for which the areas are best suited in view of their nature, the situation, and the existing needs. Priority shall be given to the use that promotes good management from the point of view of public interest. These are areas of national interest for fishery, mining, nature preservation, outdoor recreation, wind power, etc.

Network for wind utilization (1)
The Swedish Energy Agency is the expert authority appointed by the government to promote the development of wind power, taking a holistic approach to encouraging the rapid expansion of wind power. Therefore, the Swedish Energy Agency has started a national network for wind utilization. A national network important for putting to use the opportunities offered by the expansion of wind power for local and regional development. The purpose of the network is to disseminate knowledge of the natural resource of wind, safeguard the availability of information for facilitating the expansion of wind power, and support regional initiatives of national importance. An essential part of the network is to strengthen existing initiatives and contribute to the formation of new regional nodes in the field of wind power. An important task is also to coordinate other authorities in their work on wind power.

Vindlov.se (2)
One of the key obstacles prolonging the permission process for wind power is the
The huge number of stakeholders in the process. Therefore, the information a developer must consider is widespread, of different formats and quality, or simply is not accessible. Furthermore, staying up-to-date on this information requires considerable amounts of work. In this process some stakeholders might also be overlooked.

The website Vindlov.se (i.e. wind consent), takes a unique approach to target this bottleneck. The website follows the concept of a one-stop-shop providing information on permitting issues from nearly twenty public authorities from a wide range of sectors. This includes permission information over the whole life cycle of wind power and features a dynamic web map application as well as contact tools to wind power handlers at all authorities. Further development is planned and an English version is in progress.

The dynamic web map application (www.vindlov.se/vindbrukskollen) enables the wind power developer, the authority, and interested persons to view, share, and attach up-to-date public geographic information to a project without being a specialist in geographic information systems. The service is free of charge and shows localizations with public stakeholder interests, basic conditions for wind power, and all wind power in place and in planning. This includes detailed site and technical information for every single turbine and park, a set of different administrative boundaries, and a detailed base map as well as wind speed charts, weather radars and protection zones, restricted areas around military airports and training fields, national interest areas of different kinds, electricity trunk lines, valuable natural and cultural environments, and concession areas for mineral excavation.

In addition, the web map application functions as a geographic based e-service tool between developer and authority. The developer forms his application in the web map application including all necessary information. He then sends it to the authority via the system. The authority handles the status of the application, which is visible on the map for the public to follow the process.

3.0 Implementation

3.1 Industry Status

The expansion of wind power onshore is mostly driven by large utilities like Vattenfall and E.ON but also by others. A number of utilities, developers, real estate companies, and private persons are developing small and large projects.

The large, international manufacturers of turbines, Enercon, Nordex, Vestas, and others have sales offices in Sweden. On the component side (supply chain), the value of manufactured goods is large. The market consists of subcontractors such as SKF (roller bearings and monitoring systems), ABB (electrical components and cable), Dynavind (tower production), EWP Windtower Production, and Vestas Castings (formerly Guldsmedsjytte Bruk AB). Other companies worth mentioning are ESAB (welding equipment), Nexans (cables), and Oiltech (hydraulic systems and coolers). The subcontractors are mainly multinational companies, but smaller entities that find the wind power market relevant to their know-how are also established in Sweden.

3.2 Operational details

Wind power in mountainous terrain and cold climates is gaining more and more interest. Northern Sweden exhibits many such areas, where the wind potential is high. Wind turbines in the northern part of Sweden are facing a number of challenges not seen in areas with warmer climates. One such challenge is the risk of ice on the wind turbine blades, which will reduce production and may result in falling ice. Experiences from operation of wind power in cold climates indicate that energy losses due to ice buildup on wind turbine blades can be substantial. It is a general understanding that wind turbines in such areas have to be equipped with special cold climate packages. Such packages may include special steel qualities in towers and nacelle structures, and special types of oil and grease. The most essential thing is to equip blades with equipment for de/anti-icing. To support the deployment in cold areas the Swedish Energy Agency is supporting a number of projects financially.

In the Swedish Energy Agency support program for large demonstration projects, two pilot projects were completed during 2013. The project “Havsnäs” with a normal annual production of 256 GWh has contributed to the development in areas such as health and safety, project financing, foundation development, and production conditions in cold climates. The project “Large-scale wind power in southern Sweden’s forests” has a normal production of 140 GWh. This
project has contributed to the accumulated valuable experience from establishments in forest environments and complex terrain and production potential in geographically separate areas in southern Sweden. Both projects have contributed with knowledge in the areas of wind energy in cold climates, de-icing, construction in forested terrain, geographical differences in the conditions for wind power, large-scale projects, communication with neighbors, environmental studies, resource-building, and foundation development. Altogether, the pilot projects have facilitated the introduction and contributed to an increased interest for wind power in Sweden.

4.0 R, D&D Activities

The publicly-funded wind energy research in 2013 was mainly carried out within the research programs Vindforsk (3), Vindval (4), SWPTC (5) and wind power in cold climate (6).

The present period of Vindforsk (called Vindforsk IV) runs from 2013–2016, with a total budget of 60 million SEK (6.8 million EUR; 9.3 million USD). The program is financed 50% by the Swedish Energy Agency and 50% by industry. Vindforsk IV is organized in three project packages: wind resource and establishment; operation and maintenance, and wind power in the power system.

Vindval is a knowledge program focused on studying the environmental effects of wind power. The Vindval program is financed by the Swedish Energy Agency and is administrated by the Swedish Environmental Protection Agency. During 2008, the program was extended through 2012 with a new budget of 35 million SEK (4.0 million EUR; 5.4 million USD). The Vindval program has two research projects supported by the Swedish Energy Agency in 2013; the two projects relate to wind power impact on birds.

The SWPTC runs from 2010 to 2014. The program is financed by the Swedish Energy Agency, by industry, and by Chalmers University and has a total budget of 100 million SEK (11.3 million EUR; 15.6 million USD). The center focuses on complete design of an optimal wind turbine, which takes the interaction among all components into account. SWPTC is organized in six theme groups: power and control systems; turbine and wind load; mechanical power transmission and system optimization; structure and foundation; maintenance and reliability; and cold climates.

The program wind power in cold climate runs from 2013–2016. The program is financed by the Swedish Energy Agency and has a total budget of 32 million SEK (3.6 million EUR; 5.0 million USD). The program focuses on removing barriers that arise for wind power in cold climates.

During 2013, the program management for Vindforsk, Vindval, SWPTC, and wind power in cold climate organized the annual conference “Wind Power Research in Focus” where the researchers and organizations participated and presented research projects in the different programs. Vindval also organized the international conference “Conference on Wind Power and Environmental Impacts” (CWE 2013). The Swedish wind energy association organized the international conference “Winterwind” (6) that is a conference about wind power in cold climate and icing conditions.

5.0 The Next Term

The research programs wind energy in cold climate, Vindval, Vindforsk, and SWPTC will continue during 2014. A lot of the expected growth in wind generation capacity will be in forest areas and also in the northern parts of Sweden in the “low-fields.” The interest in those regions is prompted by the rather high wind potential as estimated by Swedish wind mapping. Substantial uncertainty, however, exists in the energy capture and loads of turbines in forested areas. The character of wind shear and turbulence is less explored in these areas and projects in the coming research program will be set up to increase the knowledge in this area. The SWPTC activities will continue developing wind turbines and to optimize maintenance and production costs.

References:

Opening photo: Wind turbines in Sweden

(1) www.natverketforvindbruk.se
(2) www.vindlov.se
(3) www.elforsk.se/Programomraden/El--Varme/Vindforsk/
(4) www.naturvardsverket.se/Miljoearbete-i-samhallet/Miljoearbete-i-Sverige/Forskning/Vindval/
(5) www.chalmers.se/ee/swptc-en/ (English)
(6) www.winterwind.se/
(7) www.energimyndigheten.se/Forskning/Kraftforsknings/Finkraft/kva-kallt-klimat/

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