

Aeolian distribution

Aeolian production worldwide

In the last years we have assisted at an exponential growth of aeolic power installed and production of electricity generated by wind. In 2015 a power of 63 GW has been installed worldwide, a 22% increase if compared to previous year, reaching a total power rising up to 433 GW: biggest contributors were China (129.3 GW), USA (74 GW), Germany (45 GW), India (25.1 GW), Spain (23 GW), with Europe as a whole covering 32.7% of world aeolic power. The 81% of installed power in the world is located in just ten countries: China, USA, Germany, India, Spain, Great Britain, Canada, France, Italy and Brazil.

Traditionally, since the beginning of aeolic era, the countries that invested and produced more have been Germany, Spain and the USA: Germany has always been the first in the ranking, but in 2011 it was overtaken by China and the United States. In the last five years a new important "outsider" has broken through, China, which from 2010 became the first country in the ranking, making it the main emerging country in the wind sector. In 2015, the greatest effort to incentivize installed wind power came from China, which registered a 30.8% increase with respect to 2014, with a production equal to 30% of the world installed power; and from the USA, which registered a 8.6% increase, with a production equal to 17% of the world installed power. Italy has always been in the vanguard in this sector and in 2013, it held the honourable 9th position in the classification of installed power, after China, the USA, Germany, India, Spain, Great Britain, Canada and France.

In 2015 worldwide aeolic energy production covered 3.7% of the total amount of electricity produced; nevertheless, in some countries it is an important part of national electricity balance: as an example, at the end of 2015, in Spain, 18% of power consumed was produced by aeolic sources, in Denmark 42%, in Ireland and in Portugal 23%.

(Source: *Renewables 2015 – Global Status Report*; EWEA – *Wind in power: 2015 European Statistics*)

Aeolic production in Europe

Wind power installed in Europe by end of 2015 reached 142 GW. The field is monitored, in Europe, by the European Wind Energy Association (EWEA), a non-profit NGO established in 1982, counting up to 700 members among which the main firms in aeolic plants making, and the most influential research institutes: it is the biggest sustainable resources association in the world. In 2015, installed wind power in Europe increased of 13,805 MW, from 134,252 MW to 147,772 MW. However there still are great disparities in the various European countries: Germany (30.4% of the total in Europe), Spain (15.6%), Great Britain (9.2%), France (7%) and Italy (6%) and together account for 68.2% of the production of wind power in Europe.

(Source: EWEA – *Wind in power: 2015 European Statistics*)

A significant contribution

Directive 2009/28/EC of the European Parliament and Council (which replaced previous Directives 2001/77/EC and 2003/30/EC) aims to establish a common framework for the production and promotion of energy from renewable sources. For each Member State, the Directive sets a target, share of energy from renewable sources, out of the final overall consumption of energy before 2020, which is coherent with the global target "20-20-20" (which means a 20% reduction in greenhouse gas emissions, 20% energy saving and a 20% consumption of energy from renewable sources) of the EC. With regard to the transportation sector, energy from renewable sources must be equal to at least 10% of overall energy consumption, by the year 2020. In 2013 the renewable sources reached 13.5% of the world demand of energy, and hydroelectric power and biomasses were the most common sources (the latter is due to the contribution of the poorer countries where biomasses are widely used for domestic heating, for cooking and for lighting). At the end of 2015, the production of wind energy in the world amounted to approximately 3.7% of global electric energy consumption. This may not seem a very significant amount, however there are constant increases in the production of wind energy every year.

(Source: eweaa.org)

Aeolic production in Italy

In 2015 Italy was at 9th place of biggest aeolian energy producers' ranking, with an installed capacity of 8,958 MW. A placement that deserves respect, if we think at country's smallness if compared to "giants" like USA, China or India. Moreover, conditions for aeolian production in Italy aren't the most favourable, given the peculiar shape of the country with this long and stretched territory, presence of high mountains such as the Alps which offer a barrier to winds; however there are many ideal places locally, especially on the Adriatic side of the Apennines and on the islands, and there are big potentials for offshore plants.

In Italy many associations care about management, research and diffusion of aeolic energy, as the "Associazione Nazionale Energia del Vento", ANEV (National Association Energy of the Wind, NAEW), which has subscribed agreements with Greenpeace and Legambiente for a sustainable and environmentally respectful development, or the "Associazione Produttori Energia da Fonti Rinnovabili", APER (Association of Producers of Energy from Renewable Sources, APERS) and an important cooperation is on stage with the "Gestore Servizi Energetici", GSE (Energetic Services Manager, ESM), to integrate aeolic-generated electricity with the national grid.

The aeolian energy production actually started in 1994, just with pilot plants or experimental ones, in the national energy balance. From this year, it persevered to give significant increases. In 1994, the aeolian energy (with a production of 6 GWh) represented the 0,02 % of the total renewable source energy amount, while in 2001, with a production of 1.179 GWh, this amount increased to the 2,14% and, in 2006, to the 5,6%, producing 2.971 GWh. In 2007 we saw the real "quality leap": the aeolian energy produced, 4.034 GWh, representing the 8% of our renewable sources energy, and the 1,2% of the national electric balance, based on the produced and imported energy. The growth of wind power has continued during years and in 2014 reached 15,178 GWh per share.

In the end of 2014, Italy owns 1,847 installed aeolian plants. Anyway, because of the morphological features of our land and the consequent wind rate, their distribution is not uniform for every region. The highest concentration of aeolian plants is in Puglia (572 farms), followed by Basilicata (263), Campania (221), Sicily (191), Sardinia (118), Calabria (111), Tuscany (89), Molise (35), Marche (35), Liguria (33), Abruzzo (29), Lazio (24), Veneto (17), Piedmont (15), Umbria (13), Trentino (9), Lombardy (7), Friuli Venezia Giulia (5) e Aosta Valley (4).

About the efficient gross power, in 2014 it was of 8, 703 MW, so distributed: Puglia (2.339 MW, the 26.9% of the national aeolian power), Sicily (1,747MW, the 20.1% of the national aeolian power), Campania (1, 251 MW, the 14.4%), Calabria (1,000 MW, the 11.5%), Sardinia (997 MW, the 11,5%), Basilicata (475 MW, the 5.5%), Molise (370 MW, the 4.2%), Abruzzo (231 MW, the 2.7 %), Tuscany (121.9 MW, the 1.4%), Liguria (58 MW, the 0.7%), Lazio (51 MW, lo 0.6 %), Emilia Romagna (19 MW, the 0.2%) e Piedmont (19 MW, the 0.1%) Veneto (9.5 MW, the 0.1%), Marche (9 MW, the 0.1%), Aosta Valley (3 MW, the 0.1%).

The energy produced in 2014 amounted to 15,178 GWh - 28.3% came from the Puglia region, 19.3% from Sicily, 13.5% from the Campania region, 12.6% from Calabria, 10.9% from Sardinia, 5.4% from Basilicata, 4.5% from Molise, 2.2% from Abruzzo and 1.5% from Tuscany.

In all the other Italian regions, the production of wind energy was less than 1%. Therefore, we can easily see how the regions of Southern and Central Italy are the most productive ones, thanks to the propitious wind conditions along the Apennine Crest and on the islands' relieves, while the Alps negatively influence the wind exploitation in the regions placed under this mountain chain.

(Source: GSE, *Rapporto statistico "Energia da Fonti Rinnovabili in Italia – 2014"*)

Future scenarios

According to OWEMES (*Offshore Wind and other marine renewable Energy in Mediterranean and European Seas*), future scenarios of wind energy systems indicate the Puglia Region as the region with the greatest extension in sq. km, that can be used for offshore plants (2,932 sq. km), followed by the Marche region (2,717 sq. km), Sicily (1,772 sq. km), Sardinia (1,270 sq. km), Abruzzo (952 sq. km), Tuscany (727 sq. km), Emilia Romagna (369 sq. km), Molise (292 sq. km) and Lazio (6 sq. km), for a total amount of 11,686 sq. km that can be dedicated to the development of wind energy. In the larger islands there is the possibility of counting on places where the speed of the wind is greater

(approximately 7-8 m/s) than the average in other sites (6-7 m/s), and the Puglia region is one of the regions with the largest number of marine offshore wind parks being developed.

Trends and evolution

Research is trying to solve what at present is the major problem of the production of wind energy: the discontinuous nature of the supply of energy due to the irregular wind regime. It must be pointed out that the gross efficiency of wind power plants, expressed in MW, defines the quantity of energy that can be produced in a determined period of time in which the plant operates, and it is the parameter that is considered in order to compare the productive possibilities of wind power generators with one another. However it must be considered that due to various factors, and first of all the variability of the wind, a wind power generator never operates for 24 hours a day for the whole year, but only for a certain number of hours. When the wind blows at speeds that are too low ($v < 5-4$ m/s) the generator does not produce energy, while when the wind speed is too high ($v > 20-25$ m/s) the plants must be shut down for safety reasons. Therefore, a very important factor, in order to determine the productivity of the plants, is the number of hours of operation. In Italy the plants that operate for the greatest number of hours generally operate for about 3,200 hours a year (i.e. for about 38% of the time, considering that in a year there are 8,760 hours). However, the Italian national average is much lower, it amounts to 1,700 hours a year. In order to solve this problem and increase the number of hours of utilization, research is trying to develop rotors that can produce energy and operate safely also with very low or very high speed winds. However there are limits beyond which no further improvement is possible, especially with regard to the efficiency at low speeds.