

Hydroelectric knowledge

What is it

The water cycle, triggered by the evaporation of the Earth's water, the formation of clouds and rain, provides mankind with the most extraordinary renewable energy source, the second after biomass. Its origin is once again the sun, the radiation of which causes evaporation. Although only 0.33% of solar energy received by the Earth leads to rainfall, it is still a remarkable amount of energy.

Water includes two types of energy: potential and kinetic.

Potential energy

Both when it falls down as rain and when it comes out of a spring, water is forced to go "downwards" due to force of gravity. We all can see the energy of a waterfall; the higher the jump, the more energy will be produced by the water when it falls. Therefore, the higher the water is located with respect to the point of arrival, the more the energy that can be potentially developed. Potential energy is therefore the energy of the water mass at rest, according to the initial position of water and its point of arrival. It corresponds to the energy contained in the glaciers and natural or artificial basins located at high altitude.

Kinetic energy

Water kinetic energy is the energy of a moving water mass and corresponds to the energy contained in the water of rivers, water streams and the sea. It depends on the speed and the volume of the moving water. Hydraulic machines transform water movement into mechanic energy. It is simple to convert mechanic energy into electric energy.

How to obtain energy

Two procedures are available to obtain energy from fresh water: water wheels and hydroelectric power plants. The former produce mechanic energy, the latter electricity. Water is a source of energy marked by numerous advantages known by mankind. That is why it has been used for 4,000 years. It is a relatively abundant source, more or less free, renewable and environmentally friendly. Moreover, its efficiency in the production of electric energy can exceed 80%. Energy can be obtained from seawater too, by exploiting its movements (waves, tides and currents) and its thermal energy (water heating) by creating artificial basins and equipment exploiting temperature difference. However, such technologies still need further development and sometimes only lead to experimental applications.

Potential development

In terms of large plants, in Italy the development of hydroelectric production has reached its peak. After having been the main source of electric energy until the 1960s (82% of the total amount), its share has decreased progressively whereas the quantity produced has remained constant (approximately 40/50 billion kW/h). During the '80s the share of hydroelectric energy had already decreased to 25%, whereas the thermoelectric production passed from 14 to 70% during the same period. The hydroelectric sector, if compared to the other renewable resources, has already reached a high value of resource exploitation. All the big hydroelectric plants have been built by now. The way to go in the future is based on small plants for isolated users, who have the chance to exploit the nearby water resources. The further contribution of those plants would be limited to 15 billion kW/h a year, a modest amount as compared to the energy needs of the country. Today, in Italy, hydroelectric operating power plants total approximately 21 MW which, in 1999, produced over 51 billion kW/h, i.e. approximately 19% of the total energy production (over 210 billion kW/h!).

Estimates at global level calculate a potential of 180,000 MW that could supply 75% of the current electric energy demand, as compared to the 47,000 MW currently installed. In general industrialized countries are characterized by large plants and there is scope for mini-hydroelectric plants. In many developing countries hydroelectric energy can represent an interesting source of energy supply, both through large hydroelectric plants and mini-hydroelectric ones. The European Union aims at moving from the current 9,500 MW of installed power to 14,000 MW of installed power by 2010.

Where it is

Water energy turned into hydroelectric energy a little more than a century ago and it has undergone a very rapid development which is still continuing in industrialised countries and developing countries of Asia and Latin America, potentially rich in resources. Also in terms of exploitation of available hydroelectric resources, Western Europe and the United States are the world leaders and use almost all the available resources. The use of hydroelectric energy is much more limited in Eastern and developing countries, where the energy produced by hydroelectric power plants could be increased remarkably. The installed capacity of Africa is remarkably low as compared to the huge potential of the continent. In this respect, a dam on the Congo river alone would allow the production of as much energy as it is produced in Italy in one year. In terms of installed capacity and energy efficiency, hydroelectric energy remains one of the most widely exploited resources to produce electric energy. In 2014 hydroelectric energy accounts for over 16,7% of the world production of electric energy, although only 10% of the technically viable water resources are exploited.

(Source: *International Energy Agency (IEA) – Key World Energy Statistics 2016*)

Hydroelectric power in Italy

In Italy 42% of energy produced in 2015 by renewable sources comes from hydroelectric. According to the data of GSE (Gestore dei Servizi Elettrici), at the end of 2015, the hydroelectric power produced in Italy amounted to 45,537 GWh. In Italy in 1938, 14.6 GWh out of 15.5 GWh total energy produced, was hydroelectric power. This source contributed to the start of Italian industrialization in the 19th-20th Century. After being the main source of electric power up to the 60s (82% of the total), the percentage of this renewable source progressively decreased, while the quantity produced remained constant. In the 80s, the percentage of hydroelectric power had dropped to 25%, while thermoelectric power production, during the same period increased from 14 to 70%.

It has been calculated that the hydroelectric potentiality of the Italian territory could be approximately 65 TW. When compared with the amount of energy produced, this indicates that the potential of the hydroelectric resources in Italy is exploited to about 90% and the maximum limit of possible exploitation has been reached. It therefore does not seem to be a sector that can expand further.

The fact that more favourable and convenient sites, from a technical and economical point of view, are already being utilized, contributes to the “closing” of this sector, and a number of technical, environmental and economic obstacles have arisen with regard to the realization of new high-capacity and high-output power stations. Consequently the future of hydroelectricity in Italy seems to consist in the realization of only the low-output.

A bit of history

Thousands of years ago mankind learned how to exploit the mechanic energy produced by falling water. The Greeks and Romans already used water mills to grind wheat. In Barbegal, France, and near Arles, an important port supplying Rome with wheat, 8-wheel water mills were found exploiting the same river at the same time (310 A.D.).

However, in Europe the exploitation of water power to obtain mechanic work was to become more common only during the 12th and 13th century. The main use was in the agricultural sector, i.e. grinding cereals, olives, salt and other minerals by means of water mills. Other machines powered by canals were developed between 1500 and 1600, although they were less common than water mills. One of the best manufacturers of this kind of machines was Leonardo da Vinci.

During the Middle Ages the water wheel invented by the Greeks became very popular. It was a sort of mill used to lift water and was used to reclaim swamp areas, to irrigate and in the mining field. The water wheel coupled with a camshaft (part of a machine that, fixed to a rotating axis, transmits a continuous rotating movement to another part of the machine by making it alternatively lift and lower) also allowed the production of an alternated vertical movement, similar to a hammer. It was used to print textiles and operate bellows, leading to a further development of the metal industry. Great technical progress was achieved following the evolution of the water wheel into the turbine, i.e. an equipment

capable of transforming mechanic energy into electric energy. The creation of the hydraulic turbine dates back to the end of the 1800s. Since then the turbine has been further developed and its current total efficiency in state-of-the-art plants exceeds 80%.