Home / Energy / Hydroelectric

Hydroelectric plants

Different types of plants

The main concept hydroelectric plants are based on is to transform the potential energy of resting mass of water and/or the kinetic energy of a water current into mechanic energy. Subsequently this energy will be converted into electric energy. Hydroelectric plants are subdivided into: big hydroelectric plants (or simply hydroelectric plants) and minor hydroelectric plants (or mini-hydroelectric plants). This subdivision depends on the power installed inside the plant and can take 10 MW as a reference value (actually in Italy minor hydroelectric refers to a maximum power of 3 MW).
This subdivision is usually reflected on different types of plants: while large hydroelectric plants usually require wide surfaces to be submerged, with a significant environmental and social impact, small hydroelectric plants perfectly integrate with the local ecosystem (it directly exploits the river current).
Hydroelectric power plants are also marked by great flexibility of use. Thanks to the modern automation systems, a few minutes are enough to make the power plant pass from the stand-by to the full power state. Thanks to this peculiarity, hydroelectric power plants are faster than thermoelectric power plants in increasing their production of electric energy during peak consumption hours.
Therefore, the hydroelectric production process is convenient not only from the economic and environmental viewpoint, but also from the viewpoint of operating efficiency.
Hydroelectric plants can also be defined according to the type of plant, i.e. regulated flow plants or flowing water.

Regulated outflow power plants

These plants are natural water basins (lakes) or artificial lakes (like many tanks) and sometimes the capacity of water basins increases by means of barriers (many times barriers are dams that are tens of metres high). It is possible to modify the quantity of water used by the power plant.
Today these are the most powerful and exploited plants, although they have an environmental impact. They can be used as energy “accumulators” during peak hours by pumping water at night. In general these plants have more than 10 MW power and reach an extremely high power: for example, Itaipu plant in Brazil has a basin of 1,460 square Km extension (4 times as much as Garda lake).

Flowing-water power plants

Flowing-water power plants were much more used at the beginning of the last century, above all to activate machine tools in some workshops. The potential of these plants today is less exploited than it could be. Moreover the environmental impact of these plants can be limited. The flow into these plants cannot be regulated, therefore the maximum capacity coincides with the watercourse capacity (except a portion, called minimum vital flow, that is needed to safeguard the ecosystem). Therefore the turbine produces energy according to the watercourse availability: if the watercourse is dry and the water flow diminishes under a certain level, the electric energy production stops.
In Switzerland flowing-water power plants satisfy the basic need for electric power.

How is a plant made

A hydroelectric plant usually includes five elements: a water collection system, a penstock a turbine transforming potential energy into mechanic energy, a generator converting mechanic energy into electric energy and a control system regulating the water flow. After being used, water is returned to its natural flow without undergoing any transformation from the viewpoint of its chemical and physical properties.
The collection system is mainly a barrage or a dam. It has to comply with very rigorous building and operating principles regulated by the law and, in the case of larger plants, monitored by the National Dam Service. The surface levelling hoses and the bottom outlet ensure a controlled management of the water in the basin. According to the characteristics

of the area where the barrage is built, different types of batters (small size barrages) or dams apply. After it has been collected, the water is conveyed into a turbine through pipes. These pipes start from the place where the water is collected and take the water to the plant where electric energy is produced. They are inclined and consist of round steel tubes (they also have valves on the head and foot that allow them to block the water passage).
The variables determining its capacity are the available head and the rate of flow. The first is the difference between the level at which the water is before entering the collection system and the outlet level. The rate of flow is the volume (measured in cubic metres) of water passing through a section in one second's time.
In order to calculate the hydroelectric potential of a site, it is necessary to know the flow variation during the year and the available gross head. Sometimes the hydrographic services install a measurement unit and collect the data about the previous flowing rates. Should the hydro-geological data be unknown, it will be necessary to measure the flow rate for one year. Each turbine contains a water intake and distribution device leading it to an impeller where the potential energy is transformed into mechanic energy. Moreover, turbines can be divided into impulse turbines and reaction turbines. In the former the whole transformation takes place inside the water distribution device and therefore they are preferred when the available head is higher (up to 1,000 metres) and the rate of flow is limited.
If the available head is lower (up to 200 metres) and the rate of flow greater, a reaction turbine is preferable to exploit the action of the impeller as well.
Solidly fixed to the turbine shaft, a generator transforms mechanic energy into electric energy. Each generator includes a moving rotor, upon which a magnet is installed, and stator, a fixed component. The magnetic field generated by the rotor transmits a electromagnetic power – electricity – to the copper coils in the stator.
Through suitably dimensioned copper cables, the electric energy, which is originally characterised by a 5,000 volts voltage, goes from the generator to the transformer. Here the voltage is increased up to 150,000 volts before the electricity is conveyed into the distribution network. The whole hydroelectric system is governed, controlled and protected by electronic devices monitoring the production process and intervening in case of failure and/or anomalous operation, stopping the plant immediately. Over the last years, thanks to I.T. and telecommunications, almost all plants are remotely operated from a limited number of control centres supervising all the necessary operations to allow the plants to work correctly.

Barrages

Barrages intercept the watercourse in a specific area. There can be two different types of barrages which differ according to their dimensions: dams or weirs.

Dams

Dams are high works that, as well as intercepting the watercourse, create a tank that is useful to regulate the flow rate. They can be hundreds of metres high. Dams can be made of concrete or melted materials.

Weirs

Weirs are modest height works that usually retain the high water within the river bed. Their maximum height is ten metres. They can be fixed or mobile, according to the bed configuration, the maximum flow rate and the need to avoid, during floods, excessive overflowing which would be dangerous in the area above the weir. Fixed weirs are made of masonry or reinforced concrete and are bound to be overcome by water during floods or flow rates that are higher than what the plant can bear. This is why they are usually shaped to avoid erosion. Mobile weirs have a fixed part, made of masonry or reinforced concrete, and a mobile part (called bulkhead) usually made of steel.

Small plants, small impact

In order to overcome the problems regarding the protection of the environment which the realization of hydroelectric power plants in areas that are particularly vulnerable and sensitive involve, the trend of the past years has been to progressively abandon the construction of large plants with a heavy impact on the environment, in favour of small sized hydroelectric power plants, the microhydro plants, which are small hydroelectric power plants with powers that are less than 100kW. These power plants are built without storage tanks or water collection areas , and can exploit differences in levels of only a few metres, enabling the production of energy even in isolated areas that are normally not served by the national energy supply network, as for example isolated inhabited locations, farms and shelters. This type of water resource offers the concerned mountain communities the possibility of a direct control of its management and use. The energy that is produced is exploited on site with immediate advantages for the local populations and without necessarily setting up imposing electricity power lines. For plants with a limited power, the intake of water is quite limited, changes in the course and the flow rate are negligible and the water that is used is returned immediately downstream of the hydroelectric power plant. The characteristics of these plants seem to be most suited to exploit the potential of the streams that are fed by waters from melting ice in a capillary manner, in isolated mountain areas that are not well served by the national network. At present a law proposal is being examined, which will also allow the inclusion of micro-hydro power plants in the net metering network, which is an exchange system with the Italian national electricity network, which enables the input of energy when one’s production has an excess and to draw energy when one’s production is not sufficient. At present this method is applied only in the case of energy produced by private photovoltaic plants.