Energy from the glaciers

A resource of energy

Most of the mountain regions in areas with a humid and temperate climate, including Italy, have a high production of hydroelectric power. This is an important item in the national energy accounts.
The water of the mountain torrents flows down great drops, which determine an optimum energetic potential, but generally the outputs of the torrents are too variable to be exploited continually. Glacier melt waters guarantee a supply of large quantities of water in the summer season, when the other courses of water have run dry. It is sufficient to compare, with equal precipitation, the summer output of water courses in the Alps and in Central and Southern Italy, to realize the importance of the existence of glacier bodies in the surface water regimen.
For this reason many hydroelectric plants in the mountain areas are fed by ice melt waters, and in very many cases water is tapped directly from the torrents that form from the glaciers. Countries like Switzerland, Austria, Italy and New Zealand were among the first to exploit the productive potentiality of ice waters. At the start of the Seventies, 64% of the energy requirement in Switzerland was covered by the production of the hydroelectric power plants, that were mostly fed directly or indirectly by water melting from the glaciers. In the Italian Alps, there are a number of examples in the mountain regions in the north, in the regions of Piedmont, Valle d’Aosta, Trentino-Alto Adige and Lombardy, where the presence of glaciers enables an intensive use of water as a source of energy.
One of the most imposing examples of exploitation of the water resources of the Alpine glaciers is the gravity dam in Dixence in Val des Dix in Switzerland. With its 285 m wall, it is the highest in the Alpine range and one of the highest in the world, supporting a reservoir with a capacity of 400 million m^3. With a network of over 100 km of underground galleries and channel shunts , it collects the waters of the Cheilon Glacier and the glaciers coming from Mount Rosa and the Matterhorn, with plants that cover an overall surface area of 357 km^2, half of which are covered by glaciers (data : Smiraglia, 1992).

The state of the glaciers

With only very few exceptions, glaciers around the world are receding, a phase which began at the beginning of the last century and briefly interrupted by a small advance of the alpine area around the 1980s. This puts at risk not only the existence of glaciers, but also an important renewable energy resource. Also the resulting ice and water therefore seem to be transformed into a source that is running out and is no longer renewed, as is the case with fossil fuels. In fact, the mass of most Italian glaciers is negative: summer melts more ice than is formed during the cold season and the mass of the glaciers decreases.
Unlike fossil fuels, whose exploitation depends on man and can be to some extent planned and programmed, possibly setting aside "strategic" reserves, the water produced by melting glaciers can only be used when it is available. This energy source depends on the weather conditions and, over the years, on climatic fluctuations, also influenced by human activity. For example, the torrid summer of 2003, hotter and dryer than average, facilitated the release of large quantities of melting water that was not fully exploited for energy production. Indeed, an artificial basin is constructed to contain only a limited amount of water and the technical characteristics of the plants are designed to produce that particular maximum amount of energy, even in the presence of an excess of the available resource.
Water resources from glaciers are therefore difficult to manage: the only certainty they offer is their availability during the summer months. For how many years will it still be possible to exploit this resource?

The state of the glaciers in Italy

The intense reduction of the area of glaciers in the Italian mountains, which has been accelerating in recent decades, is reflected in all the other sectors of the Alps and in other mountain ranges on the Earth and is certainly one of the clearest and most obvious signs in nature of the climate changes in progress and in particular of the increase in average air temperature. In addition to being the most reliable climatic indicators, glaciers represent an important water, energy, landscape and tourist resource.
According to the New Land registry of Italian Glaciers in Italy (published in 2015), there are 903 glacial bodies in Italy,

covering a total area of 370 km², equal to that of Lake Garda, present in 6 Italian regions, of which only one, Abruzzo, is not alpine. Making a comparison with the previous national glacier land registry, which was completed at the end of the 1950s by the Italian Glaciological Committee in collaboration with the National Research Council, it can be seen that the number of glaciers has increased from 835 to 903. What may appear to be a contradiction is actually not because the numerical increase is to attributed to the intense fragmentation of existing glacial units. The glacial surface area has indeed recorded a loss of 30% (157 km²), comparable to the area of Lake Como, from 527 km² to the current 370 km² (approx. 3 km² lost per year). There are therefore numerous Italian glaciers, albeit fragmented and of small dimensions (an average area of 0.4 km² can be estimated) with the exception of three glaciers with a surface area of over 10 km²: the Forni, in Lombardy (National Park of Stelvio), the Miage, Valle d'Aosta (Mont Blanc Group), and the Adamello-Mandrone complex, in Lombardy and Trentino (Adamello Park); the latter can be defined as the largest glacier in Italy, having been classified as a large unitary glacial unit due to its unusual shape, similar to that of the large Scandinavian glaciers, characterised by a plateau with many tongues.

Advantages of power from glaciers

There are many advantages in using glacier melt waters for the production of hydroelectric power. Glaciers are a source of water that is constant and sure during the summer months, unlike the water of rivers and torrents whose capacity is subjected to remarkable variations depending on precipitation. Consequently, in the summer months, when most of the water courses on the surface suffer a lack of water, the water courses fed by the glaciers instead, are rich in this precious resource. The energy obtained from glaciers can therefore be used in the periods in which the other water resources register minimum levels and due to the melting water of the glaciers it is possible to face situations of energetic emergency such as the recent summer black-outs.
The costs for the realization of a large hydroelectric power plants with all the connected structures (reservoirs, dams, channels, pipes, power plants and long distance power lines) are very high, but as most of these are plants that date back many years, the costs have partly been amortized and consequently the cost of hydroelectric power is relatively low. At present, due to economic and environmental reasons there is a preference for the construction of micro-plants that satisfy the power requirements of small local communities and are less costly and more ecological. It is a “clean” energy, as the production does not produce any polluting substances even though there are some repercussions on the environment.

Problems and solutions

Apart from the problem of having almost reached the maximum limit in the exploitation of this resource, a fact that has already been mentioned, the utilization of glacier melt waters for the production of hydroelectric power involves some technical problems, which have important economic repercussions.
One of the most important technical problems concerns the solid load that is normally transported by glacier melt waters, that is generally very high. The waters that flow from a glacier always have a characteristic milky grey colour, due to the large quantities of very fine material that are carried in suspension. This characteristic does not make the melted waters particularly suited to be used for hydroelectric purposes. In fact the reservoirs and channels in which these waters flow and are collected are subjected to the deposits of the suspended material. So that the plants can operate efficiently and so that the capacity of the reservoirs is not modified, cleaning interventions are required, and the deposits must constantly be removed. These operations are costly and technically they are not easy. The progressive accumulation of material on the bottom of the reservoirs (known as silting process) gradually decreases their capacity and also the productive potentiality, because the utilization times are decreased and also the plant’s operative life.
The waters that are rich with material in suspension also create another severe technical problem : the particles hit the mechanical parts of the turbines at a high speed and with great force and provoke a rapid wear of the same. For this reason these waters must be subjected to a filtering process before they enter the plant. The filtering operations are difficult and they lead to the subsequent problem of the disposal of large quantities of limey mud and clay, without creating damages to the environment.

Another problem that is becoming more and more serious each year is tied to the progressive retreat of the glaciers' front. Many intake or input units, including some large reservoirs, are located near the glacier fronts in order to collect the largest possible amount of water, and to avoid any dispersion in the detrital deposit. The progressive retreat of the fonts requires the adaptation of the intake units, thus requiring a continuous modernization of the structures and their adaptation to the changing position of the new front. This leads to an increase in the costs and the environmental problems connected with the realization of new structures.
As an experiment, plants which take water directly within the glacier have been realized. These structures are mainly used for research and are generally associated with laboratories to study glacier dynamics. The most famous endoglacial laboratory is in Engabreen in Norway, and has been installed in the intake tunnel dug inside the glacier.
Also the example of the Argentière glacier located on the French slopes of the Mont Blanc group of mountains, is famous. In the Sixties tunnels were dug in the ice, under the front, in order to capture the melting waters for hydroelectric purposes. A characteristic of the sub-glacial torrents, however, is to continually change their course, with sudden variations in their direction, therefore the galleries soon became useless and were transformed into underground laboratories to study basal erosion.