Hydroelectric

Introduction

Water is one of the most ancient sources for the production of energy. Today, slightly over 2.2% of primary energy, and approximately 16% of energy consumption worldwide, is obtained from the operation of 800,000 dams of which 45000 are more than 15 meters high. On a global scale, catch basins occupy approximately 300,000 square kilometres, an area that is as large as Italy. . For many countries, hydropower is an important source for producing electricity: in Norway covers 95.7% of electricity production, in Brazil, 83.8%, in Venezuela 72.8% and % in Canada 60.3%.
(*Fonte dati: International Energy Agency (IEA) - Key World Energy Statistics 2011*)

Hydroelectric kwowledge

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. North America is the first producer in the world with 58 million tonnes of oil equivalent, closely followed by Europe (51 million tonnes of oil equivalent), Asia (46 million tonnes of oil equivalent) and Central and South America (45 million tonnes of oil equivalent).
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 2009 hydroelectric energy accounts for over 16.5% 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 2011*)

Hydroelectric power in Italy

In Italy 67% of energy produced by renewable sources comes from hydroelectric. According to the data of GSE (Gestore dei Servizi Elettrici), in 2010, the hydroelectric power produced in Italy amounted to 51,117 GWh. In Europe, Italy is one of the three major producers of hydroelectric energy, together with France and Spain.
Furthermore, according to the GSE data, in Italy 1965 hydroelectric plants were active in 2000, out of which 1120 with a power less than 1MW; in that year, the production amounted to 51 TW.
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 (<100 kW) so-called micro-hydro plants, that imply a poor economic and technical commitment and have a very low impact on the environment.
(Sourcei: Impianti a fonti rinnovabili – Rapporto statistico 2010, GSE 2011)

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%.

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

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.

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. In the Nineties, hydroelectric power accounted for 34% of the total energy produced in Lombardy, 80% in Piedmont, 99% in Trentino, and practically 100% in Valle d'Aosta, compared to 22% of the overall national total.
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).

Ice: is it an inexorable resource?

With only very few exceptions, glaciers all over the world are in a retreating phase, that began at the start of the last century and was interrupted for a short period of time with a small advance in the Alpine area around the Eighties. This endangers not only the existence of the glaciers but also of an important renewable source of energy. Ice and the water deriving from it therefore seem destined to turn into a source that is becoming exhausted and that is not renewed any

more as is the case of fossil fuels. In fact the mass of most of the Italian glaciers shows a negative trend. In summer more ice is melted than what is formed during the cold season, hence the mass of the glaciers decreases.
Unlike the fossil fuels that are exploited according to the will of man, and that can be planned and programmed to a certain extent, by storing “strategic” reserves if necessary, the amount of water produced from melting glaciers can be used only when it is available. This source of energy depends on meteorological characteristics and in the course of the years, on fluctuations in the climate that are also influenced by man’s activities. For example, the torrid summer of 2003, that was hot and dry above average, favoured the output of a large amount of melted water that was not completely exploited for the production of energy. In fact the artificial reservoir that has been built, contains only a limited volume of water and the technical characteristics of the plants are designed to produce a fixed maximum quantity of energy even though the available resource is present in excess.
The water resources coming from the glaciers are therefore difficult to manage. The only certainty they offer is the great availability during the summer months. For how many more years will it still be possible to exploit this resource?
The state of the glaciers in Italy
In Italy there are approximately 800 glaciers, that cover a surface of approximately 550 km2, equal to 1/5 of the overall surface covered by the glaciers of the Alpine mountain range.
According to data of the Comitato Glaciologico Italiano (the Italian Glacier Committee) in 1999, 89% of the Italian glaciers was retreating, this condition was more marked for the glaciers in Lombardy, less in the Triveneto area and in the Piedmont-Valle d’Aosta regions. The retreating trend began after 1860, the year that is considered as the end of the last cold period, the so-called Little Ice Age. Beginning from the mid Nineteenth Century, 40% of the surface of the Italian glaciers has been lost, while the snow-line has risen 100 m. In the past 20 years Italian glaciers have lost 10 to 20% of their volume of ice. These data are troubling : if the present trend does not meet with any variations, most of the Italian glaciers will disappear in a few decades, and with them also an important source of energy.

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.

Is it a really clean energy?

Anything associated with water, including hydroelectric power, gives us the idea of a clean, eco-compatible and, especially, a renewable source of energy.
The impact of a large dam and its reservoir, or a hydroelectric power plant on the landscape certainly cannot be disregarded, and it is not only a matter of visual impact. An artificial reservoir (some can contain hundreds of millions of m^3 of water) has very strong geological and hydro-geological repercussions. Deep water and superficial water circulation is upset, and a large number of areas are created that can generate problems with regard to stability, with consequent landslide phenomena.
The network of intake channels that are necessary to transport the water from the reservoirs and from the areas in which water is collected to the power plants is often created underground, and dug inside the mountain, changing the water circulation underground, with consequences that are difficult to foresee, particularly in the karst areas.
Also for large power plants there are problems connected with the environmental impact: aesthetical aspects, electromagnetic pollution and overload on the ground. The power stations in the caves, built underground, partly eliminate the aesthetical problem but the problem of the disposal of the excavation material remains, and their realization may influence underground water circulation
Intake of water decreases the quantity of water in the torrents and rivers downstream from the power plant and upsets the river ecosystems, thus causing severe damages in the heritage of fish and nature. By law, it is foreseen that the water intake must not exceed a percentage of the natural capacity and what is considered a "vital minimum" must be guaranteed, so that the life of the water course and its ecosystems is protected. Actually in periods of drought, long tracts of the water courses are left practically dry, with the consequent damages to the environment.
The negative effects are not limited to parts of the river downstream from the plants but are felt along the entire water-network. A decreased flow of water in the water courses provokes a greater concentration of polluting substances in the water courses and also in the water tables that these supply.
Furthermore it must be added that the plants are built in mountain areas at high levels, and often these are to be found in

Parks and Natural Reserves – areas that are particularly vulnerable and that require a particular protection of the environment
In Italy, in the Alps, approximately 90% of the water courses are altered due to intake-structures for hydroelectric purposes, and only 10% of the Alpine torrents is left to flow in its “natural” state. It is easy to imagine how the utilization of a source of energy that is apparently “clean” can be transformed into a source of severe environmental damage, if it is not managed in a responsible and careful manner.

Small plants, small impact

In order to face the problem of safeguarding the environment when constructing hydroelectric plants in particularly vulnerable and sensitive areas, the trend in the past years was to progressively abandon the construction of large plants that can cause a heavy environmental impact, in favour of small hydroelectric plants, the micro-hydro plants that are small hydroelectric power plants producing a power below 100 kW. These plants are built without the need to create reservoirs or collection basins, and they exploit drops in level of few metres, and can produce energy also in isolated areas, that usually are not served by the Italian national energy network, as for example isolated housing units, farms and shelters. In this way the use of the source of water offers the mountain communities that are concerned, the possibility of a direct control over the management and use of the plant. The energy produced is exploited in the area with immediate advantages for the local populations and without necessarily having to build large electricity pylons. In the case of plants whose power is limited the intake of water is very limited and modification in the course and capacity of the water supply are small, and the water that is utilized is immediately returned downstream of the plant itself.
The characteristics of these plants seem more suited for a capillary exploitation of the potentiality offered by water courses fed by glacier melt waters in isolated mountain areas that are poorly served by the Italian national network.
At present a bill is being studied to allow micro-hydro plants to be added to the net metering network, the system that has been created in order to enable an exchange with the Italian national electricity network, through which it is possible to yield energy when there is an over-production and request the same when it is not sufficient . At present this method is applied only in the case of power produced by private photovoltaic plants.

Energy from the sea

Energy from the waves

Theoretically it is possible to convert at least five types of energy that are present in the sea: the current, the waves, the tides and the thermal gradient (temperature difference) between the surface and the floor.
At the moment there is only one power plant that exploits tides in France, while experiments are being made to exploit wave energy potential in the UK, in Norway and Japan and the thermal gradient in the United States. The European Union has just concluded a study that identifies almost 100 sites that could be used to produce electric energy from sea tides. In Italy the strait of Messina has been defined as one of the most promising sites.
Energy from the waves
The idea of exploiting the waves to obtain electric energy, although it creates some problems, stimulates engineers' fantasy. Researchers are trying to concentrate the waves in order to increase their height and their potential conversion into electric energy.
Other attempts try to use pressure variations that occur under the sea; some others use floats that “replicate” the wave motion and convey it to the generators by means of hydraulic pistons.

Energy of tides

We all know the strong pull of the Moon on water. From the regular raising and lowering of water mass it is possible to obtain energy. In order to build a tide-based power plant the estuary is barred towards the sea with an artificial damn. The energy technique exploits the difference in height between high and low tide: the so-called amplitude of tide. Obviously the amplitude of the tide has to be sufficient, as it happens in Northern France, close to Saint Malo, where the difference between the minimum level and the maximum level of the water is 12-13 metres. The hydroelectric power plant of La Rance, France, has been producing 240 MW for almost 35 years.

Sea current and tide energy

The energy produced from tide is one of the most interesting and least exploited among renewable sources. In Europe alone the availability of this energy amounts to 75 GW (75 million kilowatts). As everybody knows, as well as energy it is very important to estimate the amount of energy that can be exploited: in Europe exploitable energy accounts for 50 TW (50 billion kW/h). The turbines for the exploitation of sea currents can be (like for wind energy) horizontal or vertical axis. The horizontal axis turbines are more suitable for constant sea currents, like in the Mediterranean, while vertical-axis turbines are more suitable for tidal currents since they change direction, of approximately 180 degrees, several times during the day.

Energy from thermal gradient

The first power plant for the conversion of ocean thermal energy was created in 1996 offshore the Hawaii islands and produces energy exploiting the temperature difference between the different layers of the ocean. The solar energy absorbed by the sea surface heats it, creating a temperature difference between the surface water, whose temperature is around 25-28℃, and deeper water, up to 600 m depth , and whose temperature does not exceed 6-7℃.
Superficial water, which is warmer, lets substances like ammonia and fluoride evaporate. High-pressure vapours activate a turbine and an electricity generator; they pass into a condenser, go back to a liquid state and are cooled down by the water, which is sucked from the bottom. A 20℃ diff erence is sufficient to guarantee the production of an economically exploitable quantity of energy. At the moment there is a power of 50 kW/h, but it will probably be possible to reach 2 MW even though the costs are very high. (Many abandoned sea platforms for the extraction of hydrocarbons could be converted for the application of this technology)..