Sustainable use of resources

Sustainability and resources

When can it be said that use of a natural resource is sustainable? Generally we can say that a natural resource is used by man in a sustainable manner when, knowing its capacity to reproduce (consider fish as a natural resource) or to maintain a determined quality (for example the purity of the air we breathe) it is not exploited more than a determined threshold. When use of a resource exceeds the said threshold, it means that there will be a progressive and dangerous impoverishment, in terms of quantity (the global population of fish drops to a limit below which the species is destined to disappear) or in terms of quality (the air is so polluted that it is bad to breathe and causes severe diseases among human beings). If this “impoverishment” of the natural resource is definitive (disappearance of the species) we say that an “irreversible” damage has been provoked, i.e. it is not possible to go back and bring the species back to life. Impoverishment, instead, is considered “reversible” if it is possible to go back and recover the natural resource (polluted air can become breathable if polluting substances are no longer emitted).

Actually the concept of sustainability can only be applied to renewable natural resources that can be reproduced in times that belong to a “human scale” (for example, firewood). For non-renewable sources, such as fossil fuels, it is best to talk of optimum exploitation. In other words we must try our best to use these in an efficient manner (making them last as long as possible) and in the meantime, find technologies that allow the exploitation of alternative sources in their place, which may even be characterized by a “renewable” nature (for example to replace the energy produced by fossil fuels in the future with solar energy, which is a renewable source).

Energy issues

The development of our society is tied to energy consumption. Without energy, man would not have been able to reach the present level of wellbeing and quality of life. Without the availability of sufficient energy resources future economic development would be jeopardized. Notwithstanding recent increases in prices, energy is still “cheap”. All of us therefore are used to make use of large amounts of energy without thinking much about it, this is because we are not aware of our actual needs. The world energy panorama shows constant energy reserves, relatively stable prices, which however tend to grow, and a strong increase in the demand, particularly in the developing countries. However fossil fuels, which are the source of energy that has been utilized mostly up to date, have a downside. First of all they are destined to become depleted sooner or later. Certainly the ascertained reserves of fossil fuels have gradually increased during the course of the last 25 years, with the discovery of new deposits and a more exhaustive exploitation of the existing deposits, made possible by modern technologies. Unlike what was believed at the end of the Seventies, a physical depletion of these “fossil” resources is not imminent, we can still count on a few years (about 113 for coal, 59 for natural gas, 52 for oil) to develop alternative sources of energy. The problem therefore has only been postponed, but not for long! Another fundamental problem is that fossil fuels in many cases are a source of pollution of the environment, and in particular of the air.

This problem also sums with the disparity between nations, with regard to the level of wellbeing that has been obtained. Distribution of energy consumption is greatly anomalous: 20% of the world population (in the richer countries) uses 80% of the energy that is produced. This situation is strongly in contrast with the fundamental principles of equality among peoples, sustainable development and therefore global quality of life.

Countries like Africa or India are very poor at present (the pro capita income in some areas is greatly below subsistence level) and they yearn to increase their level of wellbeing. In order to do so, however, they need to utilize energy in greater amounts (for more factories to operate, to guarantee sufficient light and heating for the families).

Where will this additional energy come from? Probably if they follow our development model that uses mostly fossil fuels, there will be a marked impact on the environment and, as many experts believe, in the future, severe climate changes (the so-called “greenhouse effect”) may take place with consequences that are extremely harmful for human beings. The consequence is a “non-sustainable” development from the point of view of the environment. On the other hand, we

cannot prevent the poor countries from reaching an adequate economic and social development, also because the economic and social imbalance that exists between nations is a potential source of political instability, wars and strong migratory flows. Maintaining the present situation or a solely partial improvement would, in this case, lead to a non-sustainable development from an economic and social point of view.
How to solve these problems? Since their extent is international, the countries of the world are trying to reach an agreement, through all the international institutions that can have a fundamental role.

Effects on the environment

The energy issues arose in relation to the environmental issues. Use of energy greatly modifies the state of the environment and the effects can be of a local, regional and global nature. In this perspective, that is valid on a planetary scale no less than on a national and regional scale, right up to each one's home, the protection of the environment becomes a primary objective to be achieved in the development of the different energy systems.
In order to guarantee the future generations the wellbeing that has been obtained up to now, a type of development that is different from the past is necessary, a development that utilizes energy better (rational use), less energy (efficient technologies and less waste) and that uses forms that are substantially different from the present ones.
With regard to the environment and energy, one of the most important problems, which is the most well-known, is the problem regarding the decrease in gas emissions that provoke the greenhouse effect, which are caused mainly by the production of energy when burning coal, oil and gas.
The way to find a solution to this problem of environmental pollution is still a long one, but the steps that have already been taken to reach an agreement on an international scale are many. From 1972 to date in fact a number of conferences have been held and numerous international agreements have been signed to protect the environment, and in many of these topics related to the utilization of energy and sustainable development have been discussed.
Possible solutions
We can act on many fronts. Firstly, the economically developed countries can decrease their emissions from the production of energy, as follows:

- improving the performance of the combustion processes (less combustible burnt in order to obtain the same level of energy) and reducing wastes
- introducing new technologies that "hold back" the polluting substances, avoiding their dispersion in the air
- replacing sources of energy that are highly polluting with others that are less polluting or not polluting at all (among which almost all the renewable sources). In this way the level of economic wellbeing of these countries would not decrease, instead there would be a decrease in the impact on the environment.

Secondly, the developing countries can be helped by supplying them with better technologies that are currently available, those with a low environmental impact and high performance. There however still is the problem of the depletion of fossil fuels in the long term, which is the real challenge for "sustainability" that mankind must face, and its solution can only come from research and large scale utilization of renewable and clean sources of energy.

Hydrocarbons and climate change

Fossil fuels (oil, gas and coal) are, today, the most utilized sources worldwide for the production of energy. They account for over 80% of the energy consumption of the planet. Their combustion, however, involves the emission of large amounts of carbon dioxide (CO_2), whose increasing concentration in the atmosphere is considered the principal cause of climate change.
The need to satisfy the growing demand of energy on a global scale and in particular the demand of the emerging countries, is balanced by the need to contrast the risks of an impact on the climate deriving from the increase in CO_2. In order to decrease CO_2 emissions, there are various ways. The first, which can be carried out in the short term and which

can be implemented immediately is energy efficiency, in other words use of technologies that enable the consumption of less energy for an equal amount of services offered. Another possible solution is to use the renewable energies, which at present still have a modest role. In fact biomasses and assimilated materials (wood products, waste, etc.) account for 10% of the total energy requirement, hydroelectric energy accounts for 2% while the other renewable energy sources (solar, wind, geothermal, etc.) even though rapidly growing, satisfy only 1% of the world demand of energy. Also nuclear energy is a possible solution in order to contrast climate change as no CO_2 emissions are produced. Currently nuclear energy accounts for 6% of the world demand of energy, a share that is still not competitive when compared to the fossil fuels.

Comparing hydrocarbons

Among the fossil fuels, methane currently seems to be the one that will have a growing utilization in the near future, due to the fact it is relatively abundant and due to the fact that it is relatively "clean". Its molecule consists of 4 atoms of hydrogen and one of carbon (CH_4). When it burns this is the hydrocarbon that produces the smallest amount of carbon and for this reason it is less harmful for the environment. It produces CO_2 emissions that are 25% less than petrol, 16% less than liquid propane gas (LPG), 30% less than diesel oil and 70% less than coal. Its capacity to form ozone is 80% less than petrol, 50% less than diesel oil and LPG. Furthermore, emissions from combustion do not contain carbon deposits, benzene and particulate matter PM10, unlike benzene and diesel oil. Among all the fossil fuels, methane is surely the most "ecological". It is estimated that its use shall increase greatly in the near future.

The technology used for the geologic capture and sequestration of CO_2 (CCS)

Since fossil sources are destined to be the protagonists of the world energy scenario for many more years, we must act immediately, directly on their utilization, in order to reduce CO_2 emissions with regard to their combustion. CO_2 Capture & Storage (CSS) technology enables the capture and sequestration of the CO_2 generated by the use of fossil sources, reducing the emissions in the atmosphere.

With regard to the capture of CO_2, there are technologies that are already well known and utilized by the petrochemical industries and others are being developed. At present, CO_2 can be captured in three principal ways.

- **post-combustion**: in post-combustion capture, CO_2 is separated from the combustion fumes, first purified from the pollutants with modern treatment systems. This separation takes place using a solvent that absorbs CO_2 at low temperatures, that it subsequently releases for heating, generating a practically pure CO_2 current.
- **pre-combustion**: in pre-combustion capture, CO_2 is removed before combustion. The fossil fuel is gasified with oxygen to generate hydrogen and CO_2. The CO_2 is separated, while the hydrogen is utilized to generate electricity in a combined cycle, or for other uses as an energy vector.
- **oxy-combustion**: with this method, combustion of fossil fuels is fed with oxygen instead of air, thus generating a gaseous current that consists mainly of CO_2 and water vapour. The water vapour is separated through condensation and the concentrated CO_2 current can be compressed and stocked.

Once it has been captured and compressed, CO_2 is transported in pipes up to the **storage** site, and injected to a depth of about one kilometre underground. Depleted hydrocarbon deposits and saline aquifers (deep bodies of water with an enormous capacity to absorb CO_2) are considered suited reservoirs for permanent geological confinement of carbon dioxide.

The CO_2 is injected at high pressures, so that it reaches the so-called "supercritical" behaviour, in other words a state that is similar to a gas, due to its capacity to spread rapidly in the porous surfaces of the geological formation, and that is also similar to a liquid, in terms of density, and therefore a volume that can be stored. In the depleted oil or gas fields, the CO_2 fills the pores in which the hydrocarbons were trapped. In case relevant amounts of hydrocarbons are still in the deposit at the time of injection, the CO_2 can also favour the additional production of oil or gas (Enhanced Oil Recovery -

EOR e Enhanced Gas Recovery – EGR processes).

Costs and feasibility

In the practical application of CCS there still are difficulties to be overcome, that are related prevalently to the costs. The initial stage of CO_2 capture has a significant energetic and economic cost, that covers approximately 80% of the total costs of the technology. In order to act positively on this phase, it is necessary to operate on plants that emit large quantities of CO_2. Once the CO_2 is separated, it is transferred to the storage site, which must not be very distant in order to minimize the costs. For distances of a few dozen kilometres, transportation accounts for about 15% of the total cost. The final stage in which the CO_2 is injected into the ground accounts for 5% of the total cost. This, however, is the most delicate stage, from the point of view of safety, and it significantly affects the sustainability of the entire process. The injection of CO_2, however, is a process that is well known in the oil drilling world, that knows its technological and geological characteristics well. In fact, for decades the oil companies have been re-injecting CO_2 derived from the treatment of acid gases into the hydrocarbon deposits in order to maintain the pressure and to support production.
The knowledge and experience matured in the oil sector can be applied to CO_2 Capture and Storage technologies, for example in the choice of the most suitable sites for carbon dioxide sequestration. In fact the oil sector has a good knowledge of characteristics such as the porosity of the storage site, that define the potential volume that can be stored, and help to evaluate the consequences on the mechanical stability of the geological formation and any seismic effects; and to identify the characteristics of the caprocks which guarantee well sealed sites for the injected CO_2 over the years. Use of saline aquifers as CO_2 reservoirs is an option that is less mature at present, it requires the development of more know-how as these basins have not been as widely studied as the hydrocarbon deposits. On the other hand aquifer deposits are also present in areas where oil and gas are not produced and they offer a potential storage that is considerably greater than deposits that have become depleted or are on the decline.