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L'EAU EN MONTAGNE
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MEGEVE (FRANCE) - 22, 23, 24 SEPTEMBRE 2010

General Assembly

Water in Mountains

3rd international congress of upper river basins
MEGEVE (France) – 22, 23 and 24 SEPTEMBER 2010

and

« EUROPE-INBO 2010 »

"New water governance in mountains is needed to face climate change!"

THE WATER REGIME OF ALL THE LARGE EUROPEAN RIVERS, COMING FROM MOUNTAINS, IS CHANGING.

All the large European rivers, the Ebro, Rhone, Po, Rhine, Danube, Vistula… and their main tributaries have their headwaters in mountains and have mainly a snow-glacier regime, characterized by:

- snow precipitations during the cold period, allowing a natural limitation of flows and thus of floods in autumn and winter,

- water release during the warm period, with the melting of snow and glaciers to feed the summer low water levels, mainly downstream, in the large European plains.

Today, the mountains are providing an essential share to the flows of all these large European rivers, 34% of the total annual flow of the Rhine, 41% of that of the Rhone up to 53% of the flow of the Po, i.e. on the average 2 to 6 times more than their relative surface area as compared to that of each basin.

Thus for example, even though only 11% of the Rhine River Basin is located in the Alps, the latter thus provides 34% of the annual flow, but also **more than 50% of the summer flow,** when water is particularly required especially by the farmers using irrigation when rainfall is low.

Today, between spring and summer, the melting of snow and glaciers in the French Alps is about 15,000 billion m3 per year which comes in support to low water levels.

In period of drought in the plains, it would be a disaster for entire regions if the "tap" of mountain water dried up!!!

However, the European Commission has already identified 33 Basins which are affected by water shortages. They cover an area of 460.000 km^2, representing 10% of the European Union and 83 million people live there, i.e. 16.5% of the population of the EU.

The European Commission estimates that the number of EU regions and populations affected by drought has increased by 20% and that 17% of the European population suffered from droughts more or less marked between 1976 and 2006.

One of the greatest droughts occurred in 2003 affecting more than 100 million Europeans and one third of EU territory, causing more than 8.700 billion euros in losses to the economy.

THE MOUNTANS ARE THE WATER TOWERS OF EUROPE!

They play a strategic part in the management of freshwater.

Precipitations are highly variable from one area to another: for example in France, they are more than 2,000 mm/km^2 in the Northern Alps as compared to only 650 mm/km^2 in the Southern Alps.

But, the European mountains are already among the first victims of climate change!

The reports of the Intergovernmental Panel on Climate Change (IPCC), the European Environment Agency in Copenhagen, the European Commission, the Alpine Convention in Vienna and the Interministerial Group on the Impact of Climate Change are alarming.

In one century, the average temperature of the Alps has increased more than the double of total global warming, i.e. from +1.5°C to 2.0 °C, whereas the average temperature of the Earth has increased from +0.74 to +0.81 °C and that of Europe by +1.2°C.

The models forecast an increase in temperature in the Alps by 2100 ranging between + 2.6 and + 3.9°C. Warming could be significantly higher in mountains to reach + 4.2°C above 1,500 meters.

1994, 2000, 2002 and 2003 have been the warmest and driest years for 500 years…

Today, there are still 5,150 glaciers in the Alps, covering some 2,909 km^2.

But, the alpine glaciers, which have already lost between 20 and 30% of their volume since 1980, could still loose from 30 to 70% of their volume by 2050; almost all the smallest ones would then have disappeared!

The glaciers of the Pyrenees have lost 80% of their surface area since 1850 and those of the Alps 40% on the average. The glacial tongues go back in altitude from 60 to 140 meters for only an increase of 1°C in temperature.

If total annual rainfall should vary little, on the contrary its seasonal distribution will be heavily modified, with an increase in winter and spring (precipitations then falling increasingly as rain rather than snow), and with a strong decrease in precipitations in summer.

There would be a decrease in the number of days of snow cover of 40% in the North-West of the Alps and 70% in the South-East.

Falling snow would be reduced by 36% on the average and by 20% above 1,500 meters; snow melt could occur 2 months earlier; there would be virtually no snow below 500- 600 meters….

The average annual height of snowfall passed in 20 years from 4.20 meters to 3.30 meters in Saint Martin de Belleville, Savoy, the average temperature increasing at the same time by 2°C in the Massif de Belledonne.

The temperature threshold above which the precipitations fall as rain rather than snow, could be critical. The increase in temperatures and the subsequent transformation of snowfall into rain, will have a significant influence on runoff and water storage at high altitudes, and therefore on the flows restored in summer. These changes will certainly affect the mountains themselves, but will have repercussions, just as much and perhaps even more, on areas located downstream.

With the decrease in snow and glacier melt, the water regimes of all major European rivers coming from mountains are now changing.

The flows of the large European rivers with snow-glacier regime will be significantly modified: if, at first, the summer glacier flow will increase with the acceleration of the melting of glaciers, on the contrary, there would be before 2100 an average increase of + 20% in the winter flows, but a reduction of 17% in spring and up to 55% in the summer flows, especially in the central and southern Alps.

Aquifer levels could also lower by - 25% in the Southern Alps.

Flood frequency and intensity will greatly increase in autumn, winter and spring, as well as summer droughts.

The other consequences of climate change in mountains will be:

- severe erosion, landslides, big sediment transport,
- degradation in river quality,
- increase in water temperature.

Modification of mountain flora and fauna in general and aquatic ecosystems in particular may, in the medium term, jeopardize the descriptive criteria of "good ecological status" as defined for the corresponding water bodies in the WFD implementation ...

Hydropower production could be reduced by 15%; cooling of thermal and nuclear power plants at the foothills and in plains will be more difficult.

River navigation will have to adapt to less draughts…

Competition between water uses will become fiercer particularly:

- with widespread snowmaking, which will become essential for the 666 current alpine ski resorts to ensure proper winter season, and

- with the development of irrigation, to cope with higher evapotranspiration from plants.

It is essential to quickly identify these changes and their consequences, basin by basin, and to initiate now the action plans necessary to adapt upstream and in the plains downstream, in good time.

Europe has many mountain ranges in most European countries apart from Denmark, Holland, Malta and the Baltic States (*NORDREGIO study of January 2004*). Spanish Cordilleras, the Pyrenees, the Alps, Balkans, Carpathians, in the enlarged European Union, the mountain areas cover on the average 35.5% of the total territory and over 90% in Norway or Switzerland. 94.3 million Europeans live in mountains.

These mountains of Europe are vital to the people of the continent, in many respects, and have been described as **"the ecological backbone of Europe".**

In Mediterranean areas, especially in the Iberian Peninsula, southern Italy, Greece and the Balkans, or the French Riviera, mountain water is a strategic resource for drinking water, development, especially essential for irrigation, even tourism.

In France, we must remember that the water of the Southern Alps (Durance / Verdon) transferred by the Canal of Provence or the Canal of Marseilles, secures the supply of raw water to Marseilles and the entire coastal region to Toulon!

It is also necessary to consider that more than 50% of the rivers (150), lakes (50) and aquifers (170) are transboundary in the Alps and their sound management must be jointly taken care of and integrated by all the riparian countries, as now required by the European Water Framework Directive.

THIS PHENOMENON DOES NOT AFFECT THE EUROPEAN MOUNTAINS ALONE!

All the largest rivers of the World and their main tributaries have their headwaters in mountains.

The Himalayas are, after the Arctic and Antarctic, the first inland freshwater reservoir in the world and feed the major Asian rivers, Ganges, Indus, Brahmaputra, Salween, Sutlej, Mekong, Chang Jiang (Yangtze), Yellow River, which, except for the Ganges, are all born on the Tibetan plateau in China.

All together these rivers contribute to the water supply of more than two billion inhabitants…

A report by the Asian Development Bank estimates that more than 1,600 billion people will be affected by the impact of climate change on water in the Hindu - Kush - Himalayas ranges.

If in the Eastern range the Monsoon is still feeding most of the river flows, in the Western range, summer melting of ice now accounts for more than 50% of the flow of the Indus in this season.

It is estimated that over the last fifty years, the glaciers of the Tibetan plateau lost 82% of their surface area and that two thirds of them could have disappeared by 2050. The total ice mass may have fallen by 70% by the end of the century.

The World Glacier Monitoring Service (WGMS) confirms in its latest annual report that the glaciers of the world continue to melt at a quick and historically unprecedented rate and

specifies that those located at relatively low altitude in the Andes, the Alps and the Pyrenees are immediately threatened.

The development and protection of mountains are thus huge challenges on a worldwide scale, especially for the regulation of freshwater resources:

Mountain areas cover 24% of the surface of continents and about 26% of the world population lives there if one includes the people who live nearby at the foothills or in the lower valleys.

But a much larger proportion of the world population depends on the goods and services provided by these areas, **especially water**, which can be vital for agriculture, communities and industries located hundreds or even thousands miles from these mountains.

In mountain areas, small climate changes on a worldwide scale can cause major disruptions to local environmental conditions. It is likely that they will have substantial impacts on agriculture and forestry, but also on the water regime.

Mountain ecosystems are very sensitive indicators of climate change.

The mountains are characterized by great climate variability and conditions change rapidly over short distances, there are many microclimates depending on the slope and altitude, exposure to sunlight and prevailing winds and many other factors. Because of difficult access and low population density, often located in border areas, the collection of hydrometeorological information remains insufficient and sometimes even non-existent.

Therefore, given their strategic role in water management, the World Meteorological Organization has recommended developing a denser network of observation in these mountain areas designated today as **"the blackest of black boxes in the World Hydrological Cycle".**

It is necessary to very quickly give ourselves the means to develop scenarios to better understand the evolutions and to help make arbitrations and objectify the choices which will be imposed to everyone.

According to the IPCC, the lack of water could affect between 1.100 and 3.200 billion people worldwide by the end of the century if temperatures increase by 2 to 3 °C ... The areas affected by drought will spread and, under these conditions, it becomes a priority to develop effective strategies for adaptation to drought risk.

MOUNTAINS ARE AREAS WITH NATURAL HAZARDS:

With the slope and relief, combined with clear-cut and often fragile vegetation because of a harsher climate, **the mountains are areas of severe erosion and rapid concentration of water**, causing high water levels and floods which can be disastrous for the lower parts of river basins and plains.

The effect is even more devastating as the flatter areas of the valley bottoms are narrow and steep between the slopes, and as infrastructures, activity areas and housings are concentrated there, and that urbanization is not adequately controlled ... hence the importance of plans of exposure to natural hazards!

These situations can be worsened as a result of human activities:

- Overgrazing and deforestation in many Southern countries, which cause erosion and landslides,

- The sealing of soil by buildings, parking lots and roads, especially in areas with strong urban and tourist development, which prevents infiltration of water into the soil and intensifies runoff,

- Cultivation of grasslands in some areas,

But also, conversely,

- Abandonment of the most difficult sectors by the population and traditional economic activities, such as pastoralism, with, for consequences, the destruction or the lack of maintenance of collective hydraulic works, terraces and drainage systems in particular, and the return to wasteland…

These mountains also "produce" alluvium (mountain debris accumulating downstream), which will settle in the plains, causing damage to the environments (clogging of spawning grounds, diffuse pollution).

With climate change these risks will worsen and manifest themselves by flash floods causing deaths, landslides, collapses of cavities or rock falls which can cause damage to built infrastructures and the stopping of transportation routes (roads and railways) in the mountains.

The high sensitivity of mountains to climate change can quickly undermine protection works, built-up areas and infrastructures, especially roads and railways, and cause or worsen natural disasters such as floods, landslides and avalanches.

In urban areas of valley bottoms and plains, it will be necessary to pay attention to the sizing of sewerage systems to compensate for the increased risk of flooding due to storm water.

These phenomena are even more dangerous as storms are more violent and as the upstream concentration basins are steeper and lead directly to low-lying populated and industrialized areas, as it is the case in Mediterranean areas. We all remember the Cevennes torrential floods in the Gard and Hérault or those of Vaison-la-Romaine ... and recently in the Var.

In these Mediterranean mountains, the risk of floods (flash floods) will increase with the frequency and violence of the autumn and spring storms bursting into torrential rains falling on watersheds with very short and steep slopes, and on dry and bare soils unable to absorb them, especially as their water proofing will have been increased by land clearing, conversion of agricultural land, buildings, tarring of roads and parking lots and infrastructures ... But this is not surprising because since ancient times, it has been well known that the Mediterranean coastal rivers are characterized by violent floods followed by severe low water!

COMPETITION BETWEEN WATER USES IS BECOMING FIERCER AND FIERCER:

Increased water needs in upper river basins, coupled with the effects of climate change, raise doubts as to the sharing of water, available upstream, and to the availability of resources for downstream areas.

The strategies of populations and even countries may be competitors: for example, Egypt, downstream of the Nile, is entirely dependent on the development of the upstream countries, but, conversely, Turkey, with the "Great Anatolia Project", entirely controls the waters of the Tigris and Euphrates. It is the same with China upstream of several very large transboundary rivers, which rise on its territory, especially on the Tibetan plateau.

Until when will we be able at the same time:

- **in summer**, especially in dry years:
    - to secure the drinking water supply to cities, villages and tourist areas?
    - to store water in the dam reservoirs waiting **for the production of "renewable" electricity** when needed, i.e. in winter, during the peak power consumption,
    - to maintain a "**reserved flow**" for low water levels to preserve aquatic fauna and flora (environmental flow) and to allow the free upstream migration of fish (salmon,…),
    - to give more and more water to the **farmers** who will increasingly need it to irrigate their crops,
    - to ensure sufficient water in torrents for the practice of "**water sports**", canoeing, rafting, whitewater swimming, "canyoning",… to develop summer tourism,
    - if necessary, to transfer water from "water-rich" basins to basins already in deficit and on what terms (see the debate on the Spanish National Hydrological Plan!).
- **in winter**, to reconcile the making of artificial snow with the drinking water needs of tourists, when low water is generally observed in January or February in high mountains?

More specifically, winter tourism based on skiing will become difficult to preserve in middle mountains, causing economic losses for municipalities and contractors, creating an even stronger demand for stays at resorts located at higher altitudes.

In recent years, snow cover on all the mountains has already decreased significantly. Faced to these findings, the ski resorts had to invest in equipment for the production of artificial snow (46 million euros in France in an average year). This use of "snow guns" potentially provides for regular frequentation (for how much longer?) during the tourist season, but has impacts on the mountain natural environment.

Once used only to improve some parts of tracks or allow tourists going back to the resort with skis on their feet, snowmaking now provides snow on most of the tracks from mid-December to April.

For example, these “snow-blowers” or **"snow guns"** as called today, guarantee the beginnings and ends of seasons of ski resorts, and consume enormous quantities of water at times of low water levels in winter in high mountains, (January-February), when water needs are also at the highest for tourist communities, with the arrival of tens of thousands of tourists!

The development of these facilities for **producing artificial snow**, observed in recent years, which ensures the economic viability of ski resorts, has implications on water resources during winter, even if, when snow is melting, the volumes used return to the natural environment.

To illustrate this matter, a study carried out by the Water Agency has identified 162 winter ski resorts in the RM&C basin, mainly distributed into seven departments: Isere, Savoy, Upper-Savoy, Alpes-de-Haute-Provence, Hautes-Alpes, Alpes-Maritimes, Eastern Pyrenees.

85% of these resorts in the RM&C basin would have such snowmaking facilities. Snow-covered areas represent on the average **15% of the skiing areas**, with variations of 5-60% depending on the resort.

The guns are currently installed mainly below 2,000 meters. This corresponds to the altitude of small resorts, at the "foot of the tracks" or at "resort return" of the larger resorts.

However, the proportion of equipment located at high altitude is not negligible and it is likely that eventually there will not be only the resort bottoms to be equipped but the entire surface area.

"Theoretical" consumption is **1 m^3 of water for 2 m^3 of snow produced.** The water consumption observed in the 1999-2000 season for the 119 RM&C resorts is **10 million m^3.** This volume represents 19% of the annual volume withdrawn by the corresponding communities, for their use of drinking water. This is the equivalent of the yearly consumption of a city of 170,000 inhabitants.

In addition, if we look at water consumption compared to the snow-covered hectare, available data lead to a ratio of **4,000 m^3 per hectare**.

We can then compare it to what is observed for other uses, irrigation for example, as a reference, we will quote the ratio for irrigation of maize in Isere: about 1,700 m^3 per hectare.

There are still a quarter of the resorts **(37 resorts)** that take water directly in the torrents, which represents about **3 million m^3 of water**.

A RM&C ski resort has a borehole dedicated to supply the network of artificial snow, which represents a volume of 80,000 m^3.

The solution most used by the resorts is the **creation of earth dam reservoirs,** which can have a large volume of water immediately available. Thus, the operators can produce great quantities of snow, as soon as cold weather conditions are favorable. About half of the resorts **(70 resorts)** are equipped with such storages for a volume used of **5 million m^3 of water** per year.

Snow making using these reservoirs has the advantage of "shifting" in time the abstractions from rivers, thus avoiding a demand on the resource at the time of low water levels.

However, it is certain that these reservoirs raise other environmental problems: the areas likely to accommodate such developments in mountains are few. In most cases, these flat areas are wetlands, also subject to regulation for their conservation.

In addition, special attention must be given to the risk of failure of these dams, which could raise problems for municipalities located downstream.

The main use of water in mountains is drinking water.

But in winter, the population of mountain tourist communities can be **multiplied up to ten times** during holiday periods in high season.

The water needs are thus huge and sometimes critical because of scarcity of the resource at that time.

The outcomes of the investigation made by the RM&C Water Agency, show that over a third of the studied municipalities are facing water supply problems in winter. The reasons are varied: insufficient resources due to low water levels at high altitude, low yields of networks, artificial snow. The latter is still quite rare.

The abstracted annual volumes are generally still compatible with the needs of the concerned natural environments. However, the situation may be different if we reason on a 4-month-long season (low water periods) or if we study the impact on a daily or even hourly rate.

If the current situation does not seem too alarming in terms of water resources, it could become so in the future, due to the continued expansion of the production of artificial snow, which is announced in the coming years.

Artificial snow is becoming a strategic stake for many resorts and even a factor of economic survival for some low-lying resorts. It was mainly used so far to compensate for the lack of natural snow, i.e. at low to medium altitudes. Now it is more often an "all snow" objective: the aim is snowmaking on most tracks to stabilize the maximum frequentation and therefore the turnover of the resorts.

Finally, given the steady improvement in technological performances for making artificial snow, water supply tends to be the main factor limiting production after temperature conditions, the rise of which will significantly disrupt the economy of low-lying resorts, also preventing the production of artificial snow.

It is absolutely necessary to closely follow up the evolution of water resources in mountains, if we do not want regulation to be done by disasters!

Already in Spain there is a decrease of -7% in the average flow of rivers, with for consequences restrictions on irrigation and an increase in the price of drinking water in several large cities including Madrid (+0,40€/m^3)… .

Worldwide, over 1,700 billion people live in "water stress" areas; many large cities have exhausted their closest resources and need to get supply further away, creating use conflicts with neighboring areas.

A very large part of the water abstracted in the World and even in Europe is not measured or even recorded by the authorities.

Today in the EU, the WFD requires the implementation of systematic monitoring of water abstractions.

In France, the Interministerial Group on the Impact of Climate Change estimates that from 2030 to 2050, the water deficit at summer low water level could vary between 500 million and three billion m^3, including in the French regions already classified as deficit, with an average deficit estimated at about 2 billion m^3 per year. The cost of this deficit would be quantified between 5 and 10 billion euros ...

This high figure is however not huge as it only represents 2% of total renewable resources in France, but obviously much more brought back to the low water levels in the only areas concerned, which are already experiencing structural deficit today in dry summers. The planned building of additional reserves or transfers from other basins may be considered as part of a dialogue among all the stakeholders ... but this will probably be difficult?

THE QUALITY OF WATER AND AQUATIC ENVIRONMENTS IS DETERIORATING:

It is not because water is bubbling that it is clean: springs and torrents in high mountains can also be polluted by alluvia, animal husbandry or human activities!

In the past decades, we were mainly concerned by the “black spots” downstream of the large rivers, by large industrial or urban pollution in the plains, but on the small "trout streams" at high altitude, which are still, thanks God, in rather good condition, the effect of development, industry, tourism or stock breeding is proportionally more degrading, because of generally low flow, especially in periods of low water levels.

Specific but persistent **sanitation** problems, related or not to tourist activities, or **diffuse pollution** (nutrients, bacteriology), related to animal husbandry (buildings, manure management, watering) or to the dairy industry (cheese factories, pigsties) is still exerted on small rivers with an impact worsened by **low natural flows**, penalizing the most demanding uses (WSS and water sports).

Due mostly to the lack of areas classified as "vulnerable" and the small size of farms, the Program for Control of Pollution from Agriculture has not always had quite significant development in mountain areas. However, the needs for storage of livestock manure are important because of the reduced duration of the climatic window during which land application is possible, and the relative scarcity of the lands which can receive applications.

It should be noted that there is metal pollution, especially related to the natural geochemistry of the rocks, but which can be worsened locally in the old mining sectors.

The impact, in some valleys **of traditional heavy industry**, metallurgy, special steels, carbon chemistry, explosives ... can be significant.
The alpine Arc and other tourist mountains still encounter pollution problems mainly due to their high frequentation and tourist concentration in the resorts over short periods.

Artificial snow has, it seems, no impact on water resource quality. However, some vigilance is maintained because the knowledge gained about additives is still limited.

Climate change will also affect the rise in the average temperature of water, especially during summer low water levels.

However, the most significant impact comes from the installations built on the Mountain "Water Bodies": hydropower dams, sills, dykes and… thus mainly concern the basins of the Doubs, Ain, the Northern Alps, Isere, Lower Dauphiné and the Durance.

The mountain **aquatic environments and wetlands** are characterized by **their richness and density**, we note their **disappearance or degradation** or the deterioration of their functionalities on vast territories, because of diffuse damage (drainage, re-sizing of small, even very small streams, ...).

But more importantly, most alpine rivers and torrents have been dammed or channelled over the centuries and many dams and sills have interrupted the longitudinal passage and continuity of flows.

There are still very few natural rivers in the Alps. Out of the 12,300 km of the French alpine rivers, 3,500 km are rather heavily modified, including 1,000 km probably irreversibly.

These installations have a strong impact on hydromorphology and have as consequences the reduction of natural sediment transport, the erosion of the river beds downstream, the lowering of groundwater, the difficulties met in the upstream migration of fish and a loss of biodiversity.

The rivers' natural systems are few in the Alps and those that remain must be protected for the conservation of plant and animal species at risk and continuity must be restored to ensure the upstream migration of fish species. Do not forget that the Alpine rivers flow into the Mediterranean, Black Sea and North Sea, etc.

MOUNTAIN LAKES HAVE A STRATEGIC IMPORTANCE:

There are 27 lakes in the French Alps, nine of which are natural (9) including the five largest lakes, Leman, Annecy, Le Bourget, Paladru, Aiguebellette, which, with a surface area of 660 km^2, represent a volume of 94.000 billion m^3, **and 18 are man-made (18)** for a surface area of 88 km^2 and a capacity of only 3.800 billion m^3, including 1.300 billion for the Serre Ponçon lake alone.

The role of the alpine lakes to provide water downstream in dry periods will be increasingly important, but also limited by relatively reduced capacities and by the interests of the populations living on their banks. Many natural lakes have been regulated for a long time to guarantee water levels compatible with the activities which developed on their banks and also already with the interests of the downstream populations.

Man-made lakes have a storage capacity of 1.800 billion m^3 in the Rhine basin, 1,900 billion m^3 in the Danube basin and 5.200 billion m^3 in that of the Rhone.
Compared to the continuous annual flows, these storage capacities only represent 57m^3/s out of 1,060 m^3/s of mean annual flow of the Rhine in Basel, 60 m^3/s out of 1,940 m^3/s of the mean annual flow of the Danube in Vienna and 165 m^3/s out of 1,700 m^3/s of the mean annual flow of the Rhone in Beaucaire….

If these storage volumes are not negligible, they can only play a limited role in balancing these mean flows from one year to another, yet they are of prime importance in the regulation of power generation (clean energy), in the guarantee of water supply at low water and the maintenance of minimum environmental flows.

However, given the small number of sites that can potentially be equipped, it is necessary to primarily focus on optimizing existing reservoirs and on new regulating pumping stations ... if it ever can be compatible with the Water Framework Directive?

Lakes can only play a "mitigation" role and the downstream populations will primarily find the solution to their problems by regulating their own demand.

WATER IS ALSO AN ECONOMIC WEALTH IN MOUNTAINS:

From the Middle Ages in Europe, **water mills** led to the installation in the upper valleys of industry, including metals, reinforced early in the twentieth century by the proximity of **hydropower** (special steels, aluminium, carbon chemistry, etc.).

- Traditionally, **manufacturing activities** in mountain areas are located near sources of energy and mineral resources, or are based on local know-how developed thanks to agricultural multi-activity.

- **Mountain water is a strategic source of power generation in Europe.**

In the Alps, many sites have already been equipped for a century and produce electricity, which is used not only in the Alpine countries, but also is exported beyond the European network.

Hydropower production is of strategic importance in times of peak consumption.

There are 554 plants of more than 10 MW in the Alps, corresponding to a total of 45,883 mega watts, including 128 plants in France corresponding to 12,552 MW and 9,000 MW outside the Rhone River itself.

In Germany, 60% of hydropower comes from Bavaria where there are 4,210 installations including 762 in the Alps.

If we only retain the facilities above 50 MW, there are 19 large dams, 6 low head plants, 6 on rivers and four compensation structures in the French Alps.

The "Durance Chain" allows, for example, mobilizing 2,000 MW in about fifteen minutes, the equivalent of 1.5 to 2 nuclear plants!

The Alps produce 20 TWh / year, or 4% of French electricity production of 535 TWh / year, of which 12% comes from hydropower. While this may seem small it should be reminded that this potential is strategic as it can be mobilized in periods of peak consumption.

The Water Law of 2006 introduced new rules on limiting the environmental impact and on reserved flows, which should be implemented before 2014.

In the Rhone basin, nearly all developable sites are already developed: one project is planned in the Romanche to replace six low-head structures with a single high head installation.

The improvement of existing facilities should increase output by +2 TWh / year in the Rhone basin.

In the Alps as a whole, it is estimated that there are only a few sites left that can be developed without causing damage exceeding their interest for production.

In other mountain regions, many sites have also been equipped for the installation of hydropower units, but many sites can still potentially be equipped worldwide. The construction and operation of hydropower plants undoubtedly cause damage to rivers and wetlands, but produce no emission of greenhouse gas.

Environmental costs are often very high. Among the listed consequences, we can quote the effects on the quantities of transported sediments or the increase of erosion or degradation of biodiversity along the banks, or changes in microclimate and eutrophication phenomena in reservoirs.

In all cases it will be necessary to increase the ecological requirements to minimize the effects and protect the last natural rivers. These measures should be considered in the entire basin and not only on the development site as part of a master plan, and also integrate the small installations and small power plants.

For these reasons, in the entire France, an increase of only 13.4 TWh / year, representing 19% of hydropower production capacity, would be possible in the future, mainly with the improvement of already existing sites. The French Ministry of Ecology and Energy plans for an improvement target of + 3TWh/year for hydropower before 2020.

Mountain areas play a crucial role in power supply, especially with hydropower, but in some countries with also other types of power plants. In Austria, Belgium, Switzerland, Greece and Sweden, all hydropower plants are located in mountain ranges, and this proportion is also important in other countries (Germany and Romania: 80%; Italy: 60%). This trend is hardly surprising given that the mountain ranges provide the necessary topographical conditions (height of fall) to operate such plants.

However, if we consider **other forms of energy production**, some 50% of all power plants fuelled by gas, oil and coal in Austria are located in mountain areas; in Greece the percentage rises to about 75% and in Bulgaria to about 80%. Nuclear power plants are also located in mountain areas: two out of three in Switzerland, six out of ten in Spain. **One reason for this installation is the availability of cooling water.**

Clearly, the supply of electricity is one of the major roles of mountain areas in Europe.

But with climate change, hydropower generation could be reduced by 15%.

Switzerland estimates that compared to year 1990, its hydropower production should decrease by 7% in 2035, - 11% in 2050 and - 22% in 2100 because of climate change and plans the necessity to introduce more flexibility in operating the chain of facilities, particularly in summer.

The cooling of thermal and nuclear power plants at the foothills and in the plains will be more difficult because of the increase in the water temperature of rivers where they take their supplies. For thermal power, the margins of progress are low in cooling plants and there will be a risk in case of heat waves of not being able to meet current standards for maximum water temperature of rivers.

It will probably be necessary to re-examine the rules of operation of our great hydropower reserves for each chain of facilities owing to the new energy challenges and needs for increased support to low water flows in the plains. **In any case, conflicts may arise with the increased use of hydropower.**

However with the development of air-conditioning in summer and less use of electric heating in winter, we are also likely to see a peak of electricity consumption occurring in summer when the output of the power plants and network is less effective.

This reduced efficiency of cooling systems will also be found in industry.

Hydropower development in mountains allows to some extent the storage of "virtual" electricity when there is surplus production in Europe and production when demand increases: they function as “accumulators”, including of course the “compensation by pumping” facilities. Their role is becoming increasingly important for a balanced European electricity supply system.

- **“White water” is also becoming a new “mining deposit” for the economy of sports and leisure**- rafting, canyoning, canoeing, whitewater swimming,… - all of which are slots for mountain tourist resorts,… as in Megève, where an ambitious development will allow an increase of frequentation in summer.

With climate change summer tourism should see its frequentation increasing in the European mountains.

But conversely there is an obvious risk for the future of winter tourism:

It is estimated that the profitability of the development of ski areas is guaranteed with 100 days of snow per year and that this limit lies in the Alps between 1,200 and 1,300 meters. For each degree of increase in temperature, this limit rain / snow would rise by 150 meters.

At the end of the century, there may only be 11 days of snow in winter and 4 days in spring in the South East of the Alps and it would fall to 40 days of snow in winter and 28 days in spring in the South West of the Alps.

At 700 meters high, a warming of 1 °C would lead to a reduction of 30 days of snow. For a warming of 4 °C the duration of snow cover would be reduced by 50% at 2,000 m and -95% below 1,000 meters!

In the Alps, there are already only 599 ski resorts out of 666 which are still natural ski resorts. With a warming of 1 °C there would be no more than 500 and only 404 with a warming of 2 °C …

There are 143 ski areas in which snow is reliable in the French Alps: there would be no more than 123 with a warming of one degree C, 96 with + 2° C and only 55 with a warming of + 4 °C!

In France, mountains accommodate 20.8 million French tourists each year and 2.9 million foreign tourists, representing 175 million hotel nights, i.e. a considerable economic potential.

- Finally, there is no need to talk about the **now global market for mineral and thermal water, for which most of the sources are in mountains or at their immediate foothills.**

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Adaptation of water management to the effects of climate change is urgently needed worldwide!

Assuming that humanity can significantly reduce future emissions of greenhouse gases, the harmful effects of climate change would nevertheless continue to be felt for many decades.

Global warming now seems to be unavoidable and one of the first consequences will to change the hydrological cycles.

Should ambitious measures be globally taken by all the countries to appreciably reduce their emissions of greenhouse gases, the effect on climate would only be perceptible at best at the end of the century. Changes in rainfall and hydrological cycles have already started and will probably be felt by 2040 or 2050, i.e. in less than a generation: it is thus necessary to react quickly, before it is too late and it is clear that the sole control of gas emissions will be insufficient to alter this evolution in time.

It is therefore essential to work at adapting to the consequences of climate change and, in particular, with regard to basin organizations, at developing water resources management policies, taking into account the new elements of climate change. This includes quick assessment, according to various scenarios, of the hydrological consequences of this change.

These effects combine with the significant pressures already associated with population growth, urbanization and development.

Global warming is a “multiplier of threats”, worsening the difficult situations and increasing tensions, even in stable regions!

“If the greenhouse gases are responsible for global warming, freshwater is the first victim”!

It is therefore essential to work now at adapting policies and mechanisms for managing water resources to cope with the effects of climate change. We must learn to anticipate the damage and take the necessary measures to prevent or at least minimize their negative effects, in short to adapt!

Quick action will allow reducing costs and damage.

"UPSTREAM-DOWNSTREAM COMMON CAUSE" SHOULD BE STRENGTHENED:

It is necessary to better recognize the role of mountains for the community as a whole and to better help the mountain dwellers, within integrated basin policies, so that they can manage the territories, ecosystems and mountain water resources, build the integrated equipment necessary upstream, continue to protect downstream areas against risks and provide the plains with abundant quality water, which they will increasingly need…

For millennia, although since the nineteenth century, hydropower, industry and tourism have developed in Europe and North America in particular, management of water and soil in the mountains was mainly governed by agro-sylvo-pastoral interests, which still constitute a significant part of their economies.
Now it is time to rethink the management of mountain water and soils taking into account, as a priority, the strategic constraints of water supply to the populations and agricultural, industrial and tourist economies at the foothills and in plains downstream, based on principles of common cause, compensation, payment for services rendered by mountain ecosystems and the people who manage them.

This is one of the key strategies to be prioritized to prevent the risk of water stress on entire continents!

Conservation and storage of water resources, development of slopes and lands to hold water during rainfall, management of plant and forest cover, protection of wetlands, development of protection areas…, the new regional planning policies will have to optimize the water reserves available for the community and to prevent natural hazards.

These measures will have an important cost and it will be necessary to convince the landowners, mountain communities and developers that the production and storage of freshwater are at least as important as the current activities.

It will be necessary to establish institutional and financial mechanisms for payment by the main downstream beneficiaries of the services rendered by the upper basins.

It is especially crucial to develop studies to measure the real contribution of water to the economy and human development, in short to give a "monetary" value to water resources, to be able to establish the true cost / effectiveness assessment of their management.

Water management, which in the International Authorities is still regarded as a secondary sub-goal of sustainable development or of poverty alleviation and in our developed economies as a single component of environmental protection, must become a political priority in its own right, given the challenges it represents for the future of mankind.

In France, the "Mountain Law" of 1985 had timidly paved the way, especially as regards the energy quotas reserved for mountain areas, and by strengthening mountain policy.

The French system of Water Agencies also offer the possibility of common cause between the upstream and downstream areas of their basins, ...

It is also important to now learn about vulnerability!

Current uncertainty should not be a reason for inaction. Actions and research must be undertaken simultaneously and concurrently.

Adaptation must be “flexible” and the measures to be taken quickly must be “adaptable” if conditions change even more or if the evolution does not happen as planned.

In any case, improving the "resilience" of mountains and their ecosystems is vital for the future regulation of water resources in Europe and almost everywhere in the world.

It is necessary to develop "win-win" strategies and to immediately launch programs of measures “with no regret”, whose implementation will be anyway required in all possible scenarios, since water is essential in almost all the sectors whose development depends on its availability and its quality. Planning must be made in the basins of large rivers and based on strong intersectoral cooperation and also international when river basins are transboundary.

But beyond conservation measures, it is undoubtedly the way of relating to our water consumption that will have to change to better control demand, be more economical and less polluting, to better preserve the aquatic ecosystems, etc.

Our societies will have to accept some risk against the increased frequency and intensity of floods and droughts, against which it is not possible to achieve a "zero risk": this is learning about vulnerability, but this "zero risk" has never been reached, it will be necessary to live with it in a more conscious way than today!

THE EUROPEAN WATER FRAMEWORK DIRECTIVE:

With the Water Framework Directive, the European Union has an advanced legal tool: it is the first time worldwide that 29 countries (27 Member States + Norway and Switzerland) are committed to apply such an ambitious and comprehensive instrument to achieve “good ecological status” of most “Water Bodies” by 2015, 2021 and 2027.

Several Member States of the European Union are already developing National Adaptation Strategies; in 2011, a European Information Center on the effects of Climate Change should be created and, in 2013, the European Commission will propose a Common Strategy, whose measures on water will have to be integrated into the next 2015-2021 Management Plans and Programs of Measures of the Water Framework Directive (WFD).

Addressing the consequences of climate change and scarcity of water resources and drought in particular is already a priority for the EU regional policy for the 2007-2013 period. The framework provides support for infrastructure investments related to water management (storage, supply, treatment), the development of clean technologies for efficient use of water as well as measures to prevent risks. It is essential to make sure that the granting of funds is subordinated to prior proof of use of measures aiming at saving water and guaranteeing its sound use…

Now it is necessary to act and undertake the field actions that are urgently needed: the International Congress of Megève will present field experiments that work and produce results that can be generalized or which we can use to advance.

It is now clear that the collective cost of no action would be considerable and that it is necessary to react as fast as possible to adapt before it is too late!

THE MOUNTANS MUST REMAIN THE WATER TOWERS OF EUROPE AND OVER THE WORLD!

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