SOLAR COOLING FOR A SUSTAINABLE ENERGY FUTURE

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Key words: Implementation of Plans and Infrastructure.

SUMMARY

For several years, in industrial countries, the demand of air-conditioning in Summer has been increasing a lot, especially in the service industry and the housing field. According to recent estimates by the International Institute of Refrigeration, about 15% of electrical energy produced all over the world is used for refrigeration and environment conditioning. One of the main consequences of this trend, apart from the inevitable increase of consumption of fossil sources and gas emissions, is represented by the increase of demand of electrical power in Summer which, in many cases, reach the maximum capacity of the networks.

Solar Cooling is a kind of equipment which will be able to be applied to any kind of building and will allow to produce cold (refrigerating energy, cold water and air-conditioning) using heat solar energy “no cost way” instead of electrical energy, limiting the carbon emissions into the atmosphere.

The site location is important since the latitude defines the solar irradiation and the design of plants and their efficiency.

The professional will be in charge of planning the building, carrying out all the appropriate evaluations and measurements regarding the site, the solar exposure, the materials to be used, junctions and packages of the different executives, in order to construct a building with limited thermal losses and optimize the energy produced by the solar collectors.

Solar cooling, thanks to the sun irradiation on the solar panels, produces hot water. This water, when sent to a refrigerator, leads to produce cold water which can be used in several ways, for instance for industrial works or to produce air conditioning.

Solar energy can be used also to produce cold and becomes a profitable opportunity, because the period in which there is the most high demand of air conditioning is when solar irradiation is at its maximum level and days are longer.

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For several years, in industrial countries, the demand for air-conditioning in Summer has been increasing a lot, especially in the tertiary sector and the housing field. According to recent estimates by the International Institute of Refrigeration, about 15% of electrical energy produced all over the world is used for refrigeration and indoors air conditioning. One of the main consequences of this trend, apart from the inevitable increase of consumption of fossil sources and gas emissions, is represented by the increase of demand for electrical power in Summer which, in many cases, reach the maximum capacity of the networks.

SOLAR COOLING

Solar Cooling is a kind of installation which can be applied to any type of building and allows to produce cold (refrigerating energy, cold water and air-conditioning) by using "no cost" thermal solar energy instead of electrical energy, thus limiting carbon emissions into the atmosphere. Its efficiency will be as high as the temperature and the solar radiation of the site where the system will be built or installed. In fact, the hotter, the more it will be efficient.

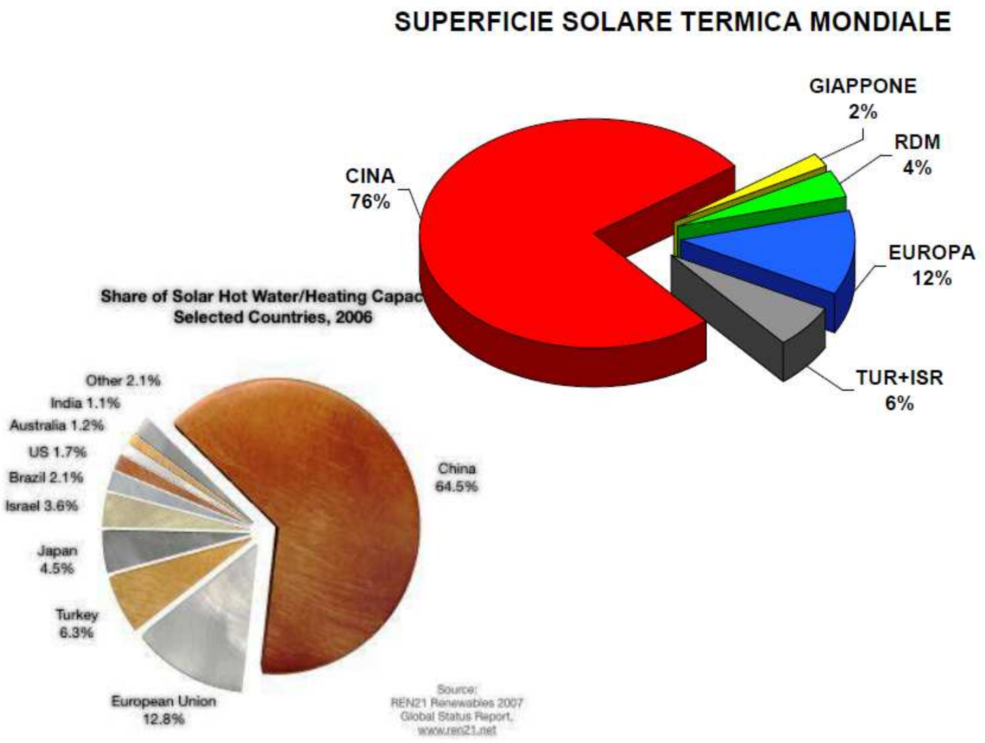

Figure 1 - Pattern on use of solar plants in the world

Solar cooling, thanks to solar radiation on solar panels, produces hot water which, sent to a refrigerator, leads to produce cold water, which can be used in several ways, for example for industrial processes or to produce air conditioning. Therefore, the use of solar energy to produce cold becomes a profitable opportunity, because the period where there is the higher demand for air conditioning is during the months in which the solar radiation is at its maximum level and days are longer.

Moreover, these air-conditioning systems have the advantage of using absolutely harmless working fluids such as water, or solutions of certain salts. They are environmentally safe and can be used to improve the indoor air quality of all types of buildings.

In Winter, instead, the thermal energy produced by solar panels can be used in a direct way, for example for indoor heating and production of sanitary hot water.

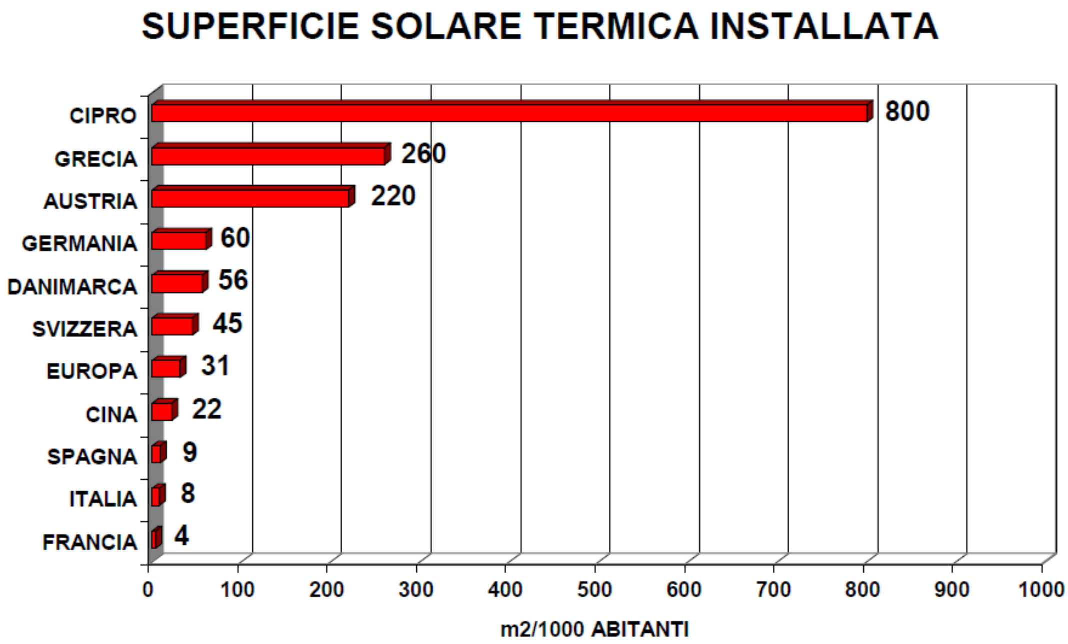

Figure 2 – Pattern on use of solar plants in Europe

Solar cooling can be applied with low prices where the solar radiation is optimal all year long and in those buildings where there is a continuous and high demand for thermal energy. It will be a task of the professional in charge of building design to perform all the necessary assessments and surveys regarding site, sun exposure, materials to be used, nodes and packages of the construction details in order to construct a building with limited heat losses, thus optimizing the energy produced by solar collectors.

PRINCIPLE OF OPERATION

The general principle of operation is the production of cold starting from a source of heat. The simplified diagram of operation of the solar cooling technology is the following:
• solar panels absorb the sun radiation and convert it into water or hot air;
• the water or hot air produced by the panels passes through the refrigerating machine, which turns it into water or cold air;

• the water or cold air is used to cool indoor environments, or for industrial refrigeration. The air / cold water is brought to the particular areas of the building through a system of ducts or a distribution network.

The principle of operation is exactly the same as that for the production of hot water, but the solar collectors to be used for air conditioning systems have to operate at higher temperatures. In fact, the refrigeration machines which they are connected to in order to work require an operating temperature of the heat vector higher than 80°C. This temperature can be obtained where we have an excellent solar radiation or, for the most unfavourable latitudes, by using high efficiency solar collectors such as vacuum collectors.

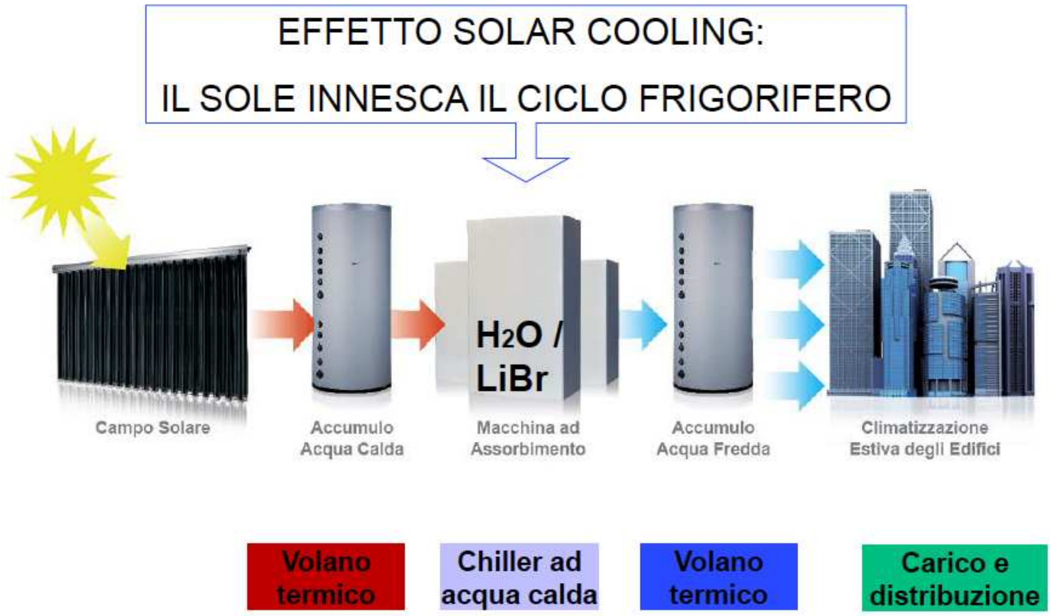

Figure 2 - Principle of operation of solar cooling

SOLAR COOLING APPLICATION

This is a 600sqm mosque located in a hypothetical country in the North of Africa between the Mediterranean area and the beginning of the Sub-Saharan zone. The site location is important because the latitude defines the solar radiation and thus the plant size.

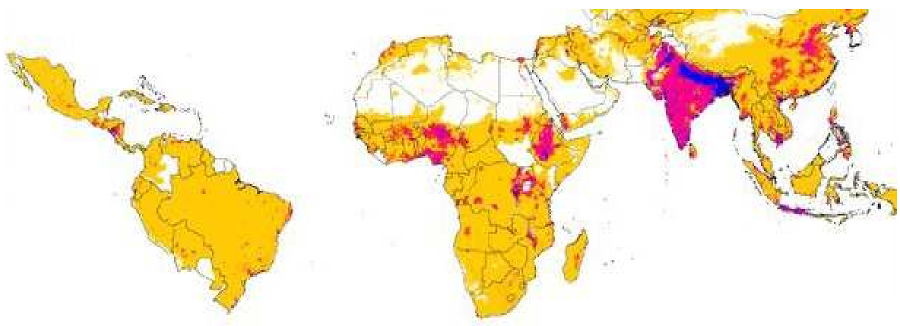

Figure 3 Sub-Saharan zone – In Africa. It's the yellow-highlighted part below the Sahara desert and near the Equator.

The Mosque energy demand is 150 watts/h per sqm (note that this figure takes into account heat losses, features of the building with very high rooms and power necessary to process the fresh air put into the rooms through the air processing units).

Figure 5 - A typical example of Mosque - we are in Touba, the main religious centre in Senegal which boasts the largest and most imposing mosque in the Sub-Saharan Africa. This huge religious complex was inaugurated in the Sixties, after 32 years of works. Today it is a pilgrimage destination and a landmark for many Senegalese of Islamic faith.

The installation will operate with water which, thanks to the sun, will be heated to 85°-90°C. The hot water will pass through a refrigerating machine that will turn it into cold air in order to cool the building (energy requirements of a 90kW refrigerating machine).
In order for the installation to operate, a field of vacuum tube solar panels will be installed that, in its peak production, will supply a thermal power of about 140 kW. The exceeding thermal power will be used for the production of sanitary hot water (showers, toilets, etc.) by means of an appropriate heat accumulator of about 2,000 lts.

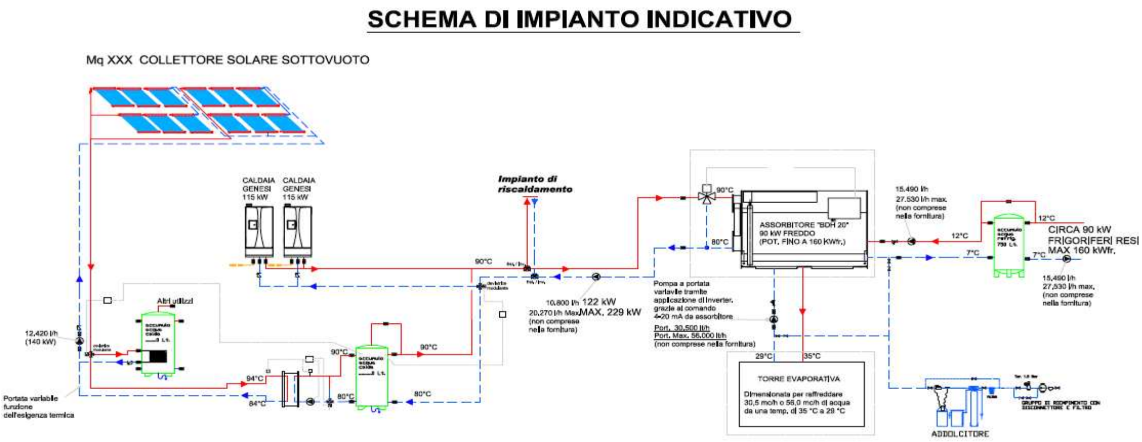

Figure 4 - Type scheme of the above-mentioned installation used for the mosque.

The installation has two storage tanks, one for the water heated by the collectors and not used and the other one for the refrigerated water which is also not used. They are necessary in order to meet the installation demands which are often discontinuous.
Moreover, the system requires the installation of a cooling tower which is necessary to dispose of the exceeding heat resulting from the solar panels and not used by the downstream plant.
However, the cooling tower can be profitably replaced by an energy recovery system for other uses (for example, to heat swimming pool water or to supply energy by means of an appropriate generator to gymnasiums, hospitals, clinics, schools and other near public facilities), which makes the whole system even more efficient.
Two support boilers are necessary if, for reasons of weather or season, the required heat cannot be supplied.
The above-mentioned solar field will be composed of about 50-60 vacuum solar panels of 3.3 sqm each for a total surface involved of about 450 sqm (pipes, panels, maintenance spaces).
Each panel produces 1.9 to 2.3 kw (1 sqm produces about 0.7kw) and thus the whole installation will produce 315kW of power used for the operation of the installation itself and for the air-conditioning of the mosque, while the surplus can be used as explained previously.
You can also say that the benefits of a solar cooling system do not only mean lower management costs but also a less impact in terms of carbon emissions into the atmosphere.
It should also be reminded that the efficiency of a solar cooling system is as much higher, as the more the downstream request appears to be continuous, reliable, and equal to the thermal power absorbed by the solar field.

ESTIMATED COSTS

We can assume an annual operation of approximately 198 days in the air-conditioning stage.
The traditional cost of a non-solar-cooling system (intended only as cold generation installations and not downstream installations because they are all the same) would be around € 70,000.00.
The estimated cost of the solar cooling generation system would be around € 120.000,00. The difference appears to be approximately € 50.000,00.
We should keep in mind that a reasonable power consumption of a conventional installation is around 45 Kw/hour that multiplied by 12 hours/day and 198 days/year add up to a total amount of about 106,920 Kw. By assuming a Kw cost of € 0.3, we get a total annual consumption of € 32.080,00.
A solar cooling system would consume an average of about 20 kW/hour that multiplied by 12 hours/day and 198 days/year leads consumption to about Kw 47,500. By multiplying by € 0.3 Kw this figure, we get a consumption of € 14,250.
Therefore the payback average time is approximately 2.8-3.2 years.
The estimate is necessarily approximate because it depends on several factors including, not least, the cost of electricity, which is particularly high in many countries, not for generation costs, but for distribution costs.

FUTURE DEVELOPMENTS IN SOLAR COOLING

The technologies which solar cooling is based on are now known and studied in several universities and research centres around the world.
At the end of 2009, the existing installations were approximately 300 (almost 20 in Italy), but nevertheless they are still prototypes, while the spread for a daily use is still zero. The main reason is due to the high costs of this technology. And it is precisely here the challenge, that is: developing a solar cooling system at lower prices, with costs more accessible to families and businesses. It will be important to focus on appropriate forms of incentives, for example: the mechanism of tax deduction of 55% currently secured for solar collectors is already sufficient to reduce the pay-back period, in the

most favourable cases, under ten years; all the more so, the introduction of a sort of energy account could support the commercial growth of this sector very effectively.

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