FIG WORKING WEEK 2012

May 6–10 2012
Rome, Italy

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S O L A R C O O L I N G

F O R A S U S T A I N A B L E E N E R G Y F U T U R E

MARA MORBIN - ITALY

… solar cooling!

THE PROBLEM

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 are:

✓ the inevitable increase of consumption of fossil sources and carbon emissions into the atmosphere (about 230-400 kg per year per person – main cause of greenhouse effect);

✓ the increase of demand for electrical power in Summer which, in many cases, reach the maximum capacity of networks.

POSSIBLE SOLUTION

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.

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.

The efficiency of a solar cooling system will be as high as the temperature and the solar radiation of the site where the system will be built or installed.

SUPERFICIE SOLARE TERMICA INSTALLATA

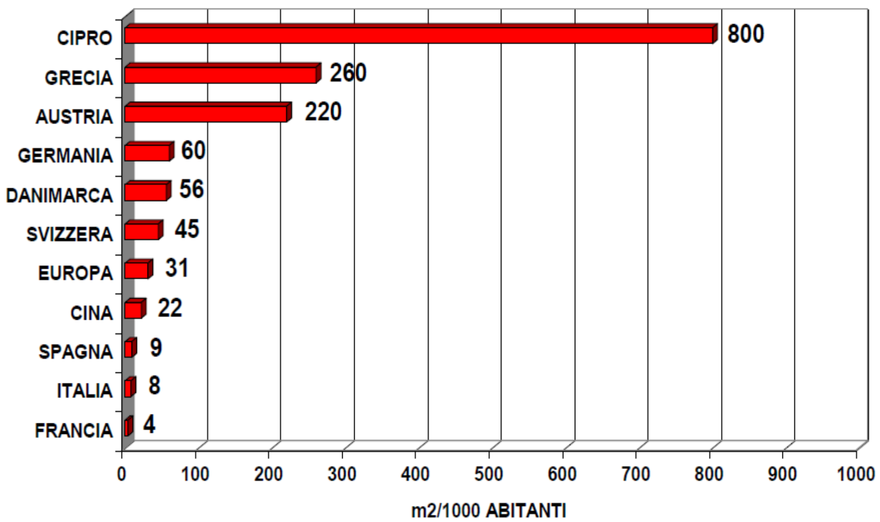

Table 1 Solar thermal surface per sqm per one thousand inhabitants.

… solar cooling!

CONDITIONS FOR THE USE OF SOLAR COOLING

Solar cooling can be applied with low prices where
- ✓ the solar radiation is optimal all year long;
- ✓ 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 carry out:
- ✓ all the necessary assessments in order to evaluate the real feasibility and convenience of the system;
- ✓ surveys of geographical site, sun exposure, orientation;
- ✓ surveys of the construction type of the building: materials to be used or used, details of execution, thermal and insulated packages, etc. in order to construct a building with limited heat losses, thus optimizing the energy produced by solar collectors;
- ✓ surveys of the surface where the panels are to be installed (soil or roof type; slope…);
- ✓ type of solar collector to be preferred;
- ✓ quotation requests and offer evaluations (guarantees, maintenance, pre- and after-sale services).

Analyzing and knowing how to size the system according to the actual needs of the building and considering the needs of the people living there is essential because, thanks to these evaluations, the system is properly sized.

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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.

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.

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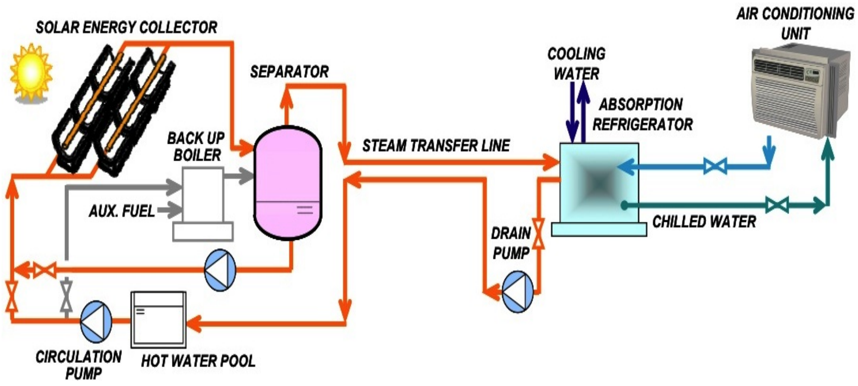

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SOLAR COOLING APPLICATION

Mosque of Touba – Senegal

This is a 600sqm mosque located in Touba in Senegal.
It is 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.
Touba is located in the sub-Saharan area with warm, tropical climate, a dry season and a wet one; but the north-eastern area borders with the Sahel and could follow its destiny of drought: Senegal is, in fact, one of the most threatened countries by desertification.
The site location is important because the latitude defines the solar radiation and thus the system size.

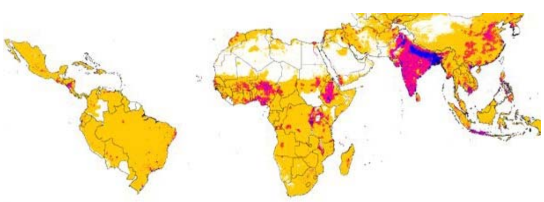
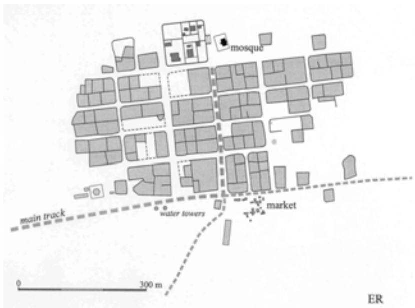


Figure 4 Sub-Saharan zone – In Africa. It's the yellow-highlighted part below the Sahara desert and near the Equator.

GEOGRAPHY

GEOGRAPHY / MOSQUE OF TOUBA - SENEGAL



IMAGES









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SOLAR COOLING APPLICATION

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).

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.

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 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.

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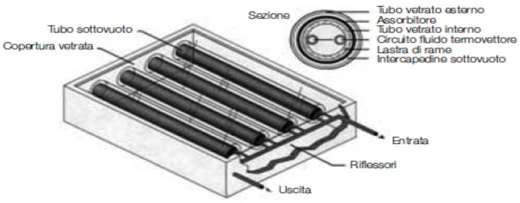
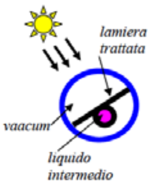
SOLAR COOLING APPLICATION

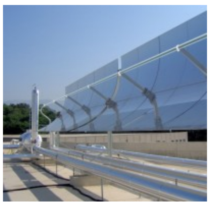
Two support boilers are necessary if, for reasons of weather or season, the required heat cannot be supplied.
The solar field will be composed of about 50-60 vacuum solar panels of 3.3 sqm each for a total surface involved of about 450 sqm (pipes, panels, maintenance spaces).
Each panel produces 1.9 to 2.3 kw (1 sqm produces about 0.7kw) and thus the whole system will produce 315kW of power used for the operation of the system itself and for the air-conditioning of the mosque, while the surplus can be used as explained previously.
Panels with circular section vacuum tubes are adopted as they are able to retain the stored heat even though there are wide fluctuations in temperature: they guarantee high and constant performance throughout the whole year. If they were used in the Nordic countries or in countries with a medium-low sun-stroke, they are generally provided with mirror concentrators behind the pipes in order to maximize solar radiation.



VACUUM TUBE COLLECTORS

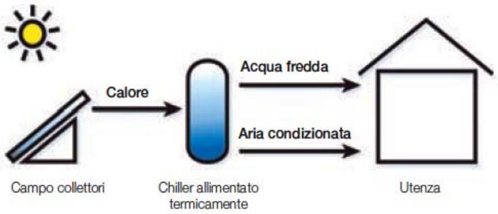
Vacuum tube collectors, in their principles of operation, are very similar to glass panels, but they have a very different structure.
They are usually composed of a series of 10-15 glass tubes, which can resist to the impact of hailstones up to 25 cm of diameter. Within these glass tubes, a vacuum is created. It has excellent insulation capacity and completely eliminates heat losses for convention by using the same principle of operation of normal thermos for drinks. The whole system is very efficient: 93% of incident solar radiation is absorbed, while only 7% approximately is lost for reflection and re-emission.
Although the temperature of absorbers can exceed even 120°C the glass tube remains cold.
The mechanism of heat transfer into vacuum tube collectors can operate in two ways:
With direct flow: the thermal vector fluid flows directly within a duct connected to the absorber inside the vacuum tube;
As "heat–pipe": the heat transfer from the absorber to the thermal vector fluid occurs within a heat exchanger.
Also during Winter, the vacuum tube collectors grant 60° hot water production without any problems.





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 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 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.



CONCLUSIONS Solar cooling is a type of system which can be sized and adjusted to the climate of the place where it will be installed and the needs of the people who live or benefit from a particular place.

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; the introduction of a sort of energy account could support the commercial growth of this sector very effectively.



Solar Cooling for a Sustainable Energy Future

THANK YOU FOR YOUR ATTENTION

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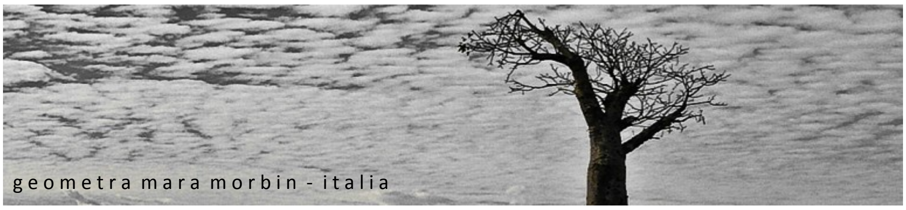
I thank theitalian surveyors National Council and surveyors graduates and theFIG



SOLARCOOLING – for a Sustainable Energy Future