Menaggio Hospital, concentrating solar plant

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Activated about one year ago, the concentrating thermal solar plant (CSP) by the Hospital Erba – Renaldi at Menaggio, in Como province, is the first of its kind in an Italian hospital.

The plant uses the tested technology of concentration by means of parabolic mirrors, which finds large application in the production of electrical and thermal energy in big plants of industrial type, situated in very sunny regions (including Andalusia, California and, in our Country, Sicily). In this case, the CSP plant at Menaggio is of "solar cooling" type: it has in fact the purpose of producing heat from the sun, then stocked and used for the conditioning of the hospital buildings, thanks to an absorption refrigerating group provided with integrative methane gas power supply system.

Programming sustainability
For highly energy-eating buildings like hospitals, the use of solar energy constitutes a real technological challenge. Our star uniformly irradiates the terrestrial atmosphere with an enormous quantity of light, equal to 1,367 W/m^2 (solar constant), but the majority of this energy is not, actually, usable. The spherical shape of the planet surface, the alternation of day and night caused by its rotation, the shielding effect of the atmosphere and the variable weather conditions make in fact its availability scarcely concentrated and discontinuous for the most diffused collection systems situated on the earth surface. Besides requiring wide areas correctly exposed to sunrays, the simplest and most diffused fixed systems (solar collectors, photovoltaic modules) are also affected by the technical problems connected with the reduced conversion efficiency, both of thermal and electrical type. The use of mobile devices, suitable for constantly orienting the exposed surfaces in optimal way and for concentrating sunrays on collection terminals, shows instead important advantages, such as:
The minor surface taken up by the plant (with the same installed power);
The higher efficiency (depending on the technology used);
The better safety for parabolas, which may slew and be arranged in safety position in case of adverse atmospheric events.

Besides, a concentrating solar plant needs adequate systems for the stocking and the versatile use of energy. In this way, it is possible to maximise the production in the most favourable periods and, afterwards, to make the accumulated energy available when requested. The CSP plant, situated by Menaggio hospital, satisfies all these requisites. It has been in fact implemented in the context of the efficiency energy programme of Sant'Anna Hospital, in Como, thanks to a funding of the Lombardy Region that has covered the half of 680,000 Euros spent for its implementation. The expected payback time of the investment is about 8 years.

CSP plant: how it is made
The hospital is located in the edge of the town, along the hillside that degrades towards the lakeside. The main compact building, inspired by a traditional concept, is arranged around three courts. Surrounded by green areas, the hospital is well integrated in the varied landscape context; the main entrance is situated downstream and is accessible from the local road network. The CSP plant has been implemented close to a pre-existing parking at grade, on two terraces facing southeast, upstream as to the main hospital building. Together with its design, they studied the construction of a second entrance to the hospital area, directly accessible from the State Road 340. The plant is formed by four main elements.

Collectors
The collecting surface consists of two linear solar collectors with parabolic section, having the same length (overall field development of

80 m; opening 4.6 m; total surface about 400 m^2). Each of the collectors is composed by 64 mirrors, each implemented by sandwich panels with structural functions (double sheet metal with inner corrugated structure, fully made of aluminium), on whose concave side they have deposited very thin layers of very pure aluminium vapours with extra-high reflection (99.7%) and transparent protective materials that make them resistant to external agents.

Receivers

Along the focus line of each row of collectors, that is to say along the straight line joining all the points of maximum concentration of sunrays, there are 40 coaxial receivers with tubular shape in all, connected one another. The inner tube (diameter 70 mm) is made of steel coated by a highly selective materials, characterized by high absorption of the sun radiation and low emission of heat in infrared. The tube is in its turn contained inside a glass cylinder with anti-reflexion treatment (diameter 125 mm). To avoid the thermal dispersion towards the outside, in the cavity that separates them, they have created the absolute vacuum, granted in time thanks to a barium and zinc getter. The whole allows the absorption and the transfer of over 96% of the sun energy collected in this way.

Structure

Collectors and receivers are mounted on a support structural steel structure, sized to grant the bending and twisting stiffness needed for the precise motion of the collector, even in windy conditions, and to bear the notable and fast thermal excursions to which the plant is subjected. The structure permits the rigid rotation of the group around the horizontal axis, by means of an electric motor with mechanical reduction gear.

Solar tracking system

The so-called tracker is based on astronomic calculation software that regulates the rotation, orienting the collectors according to the sun position in the sky, with a precision of 0.3 mrad. To grant the correct operation of the sun tracker, the calculation algorithm is based on ten external parameters (geophysical, astronomic, meteorological and time data) and it is then corrected by a solarimeter. An electronic control unit checks the environmental conditions and the state of the instruments, including accumulation tank, pump and circuits, exchanging information with the control unit through a standard data connection. The system can self-control: at the achievement of the desired temperature, the plant sets itself in stand-by conditions and in case of strong wind, rain or hail, collectors are automatically arranged in safety position.

In winter and in summer

Irrespective of the position assumed by the sun during its apparent motion, collectors automatically rotate so that the incident sun light on the specular surfaces is always reflected towards the receiver tube. In the lapse of few minutes from the appearance of the sun at the horizon, the plant quickly reaches its operational temperature, generally exceeding 180 °C (T min.: 110 °C). The heat transfer fluid used is the diathermic mineral oil, a liquid used in industrial processes that require the heat transport at higher temperatures than those of water evaporation (up to 300 °C), also at atmospheric pressure. The diathermic oil is neither toxic nor corrosive: it is characterized by low viscosity, which facilitates its sliding and permits the cold starting of circuits (operating conditions: -10 ÷ +50 °C), as well as by lubricating power and protective action of mechanisms (pumps, valves etc.). The overheated oil (700 l), which circulates in the plant at speeds included between 1 and 2.5 m/s, is sent to the stocking plant (1,300 l), with function of thermal flywheel and opportunely insulated to minimize dispersions, by which it is then sent to heat exchangers (hot water for heating, hot sanitary water) and to the absorption refrigerating group (refrigerated water). In the first case, the hot water produced integrates the thermal contribution, prerogative of heaters, and of the new cogeneration group, which will be installed by the hospital within the end of 2014. In the hot season, the use of an absorption refrigerating group (power 230 kW) allows the exploitation of the solar thermal energy for the production of cold water at 7 °C (solar cooling). The high available temperature allows in fact the use of double-stage refrigerating cycles, with cooling efficiency values (COP) equal to almost 200% compared to a single-stage absorption refrigerating group, operating with hot water. It is so attained a significant meeting between cold demand and solar energy offer: the higher is the sun radiation and, consequently the atmospheric temperature, the higher is the quantity of frigories that it is possible to produce. In case the CSP plant (solar field efficiency > 50%) cannot supply the thermal contribution requested by the absorption refrigerating cycle, the group is equipped with a modulating gas burner, which is automatically operated to increase the thermal power up to the achievement of the necessary temperatures. Mostly formed by components produced in Italy, the CSP plant has a peak power of 233 kW: it can satisfy about 30% of the hospital's yearly consumptions of thermal energy, since its energy needs in 2008 amounted to 2,080 MWh. The operation point of the CSP plant is situated at +40 °C from the flammability limit of the diathermic oil: to ensure the safe functioning at full rate it was therefore necessary to inert the system.

Giving the floor to technicians

We asked Flavio Marzorati, engineer and Manager of HU Technical Services and Heritage of Sant'Anna Hospital in Como, how they devised the project for the CSP plant. «The choice of opting for the CSP technology was mainly motivated by the possibility of avoiding the purchase of new refrigerating groups and relative cooling turrets. We could then maintain the existing electrical cabinet, which did not permit integration of deliverable power, and avoid the installation problems in narrow spaces of the new machines. Today the plant grants the satisfaction of the cooling need of about one third of the hospital. The best result achieved is constituted by the notable reduction of the overall gas consumptions for winter heating. To enhance the efficiency and energy recoveries, we have studied increased accumulations of cooled water, in order to use it also in the hours when the sun is not available. This solution has also implied a better management of the pump operation».

What solutions are under study to optimize further the plant operation?

«We are evaluating the "shaking" of the served utilities, in order to privilege the operation in solar cooling and to reserve the other refrigerating groups for the integration, if the CSP system could not grant the load. To maximise the efficiency, a further feasible measure would be the use of the exceeding heat production to produce electricity – form of energy always requested both in summer and in winter, night and day. In this case, the conceived machine would function with "Stirling effect". We are currently researching technically consistent solutions with the latter hypothesis».

Matteo Palazzetti, engineer, (Nova Engineering Project) designed and managed the implementation works of the CSP plant: «The solar energy constitutes the renewable source that, at present, exhibits the major potential of development and exploitation on European and world scale. The project matches various innovative technologies in a coordinate system of heat and cold production, set as example in the sector of thermotechnics applied to health structures, voted to a sustainable future in conditioning plants, able to define a sort of guideline also for what concerns relevant aspects, such as those related to fire safety and the proximity to the heli-deck at the service of the hospital. The plant has been studied to satisfy the energy needs of the building and, despite its strongly innovative character, slightly less than one year after its commissioning, it represents an undisputed success both in terms of efficacy and of the aspects of consumption reduction and environmental compatibility».

Thermodynamic Solar

The use of concave reflecting surfaces to concentrate the sunlight is not a novelty: in 200 b.C. Archimedes of Syracuse used them to set fire to the Roman ships that besieged the city. The same optical principles have permitted, for decades, the observation of the universe by means of enormous telescopes. The contemporary energy industry uses several thermodynamic solar technologies (CSP) for the production of thermal energy, generally in combination with turbine devices that exploit the steam force to produce electricity. The most diffused typologies are three: with central turret, on whose top are concentrated the sunrays reflected by a field of mirrors equipped with solar trackers; they are mainly diffused in the United States and in Spain; with independent receivers, formed by disks that concentrate the rays towards a focus where is positioned a turbine, which directly produces electrical energy; they are used in the United States; with parabolic mirrors: similar to the Menaggio plant, they are composed by long rows of linear parabolic mirrors that concentrate the light towards a receiving tube; they are spread in the above-mentioned Countries, in Maghreb and also in Italy.

Our Country is in the forefront in the sector of CSP with parabolic mirrors. A pilot plant has been operating for years by the Enea Research Centre at Casaccia (Rome). Enel has implemented a plant at Priolo Gargallo (Syracuse), which operates as support of the local thermo-electrical methane gas power plant. Another plant has been recently realized at Massa Martana (Perugia), for the headquarters of the Company Archimede Solar Energy, specialized in the production of high-tech systems for renewable energies.

The hospital of central Lario

Together with the new Sant'Anna Hospital in Como, the hospitals operating at Cantù (Sant'Antonio Abate) and Mariano Comense (Felice Villa) and the numerous polyclinics and sampling points diffusely spread on the provincial territory, the hospital at Menaggio (Erba – Renaldi) belongs to the Sant'Anna Hospital Agency. Thanks to its favourable position and to the supplied services, it constitutes the reference health structure for the central area of Como Lake, granting the delivery of the main medical and surgical specializations. The pole is constituted by two buildings developed on three floors above ground, plus a basement: it houses the specializations of Medicine, Surgery, Orthopaedics, Dialysis, Psychiatry, Cardiology; it relies on First Aid and Inpatient Wards (120 beds), Day hospital, Radiology, Analysis Laboratory, Surgical Block, Pharmacy as well as Technical and Management Offices.

The importance of the diagnosis

Menaggio hospital is equipped with a radiant and standard winter heating plant, with hot water integration for some sectors of the building, supplied by conventional thermal generation systems and, soon, with cogeneration systems. The summer conditioning is performed by air-cooled electric refrigerating groups. In all, the nominal installed power is equal to 2.3 TW. The energy diagnosis, aimed at identifying the consistency of plants and their relative consumptions, concerned the entire building/plants system, with the target of analysing the consistency and the energy performances of buildings and technologies, as well as the related consumptions also from the historical point of view; assessing various, mutually alternative, intervention hypotheses and the respective energy and economic benefits; identifying the most suitable intervention strategy in relation to the hosted activities.

Absorption refrigerating cycle

The production of cold fluids for the environment conditioning can occur using the thermal energy coming from a hot fluid, thanks to so-called absorption refrigerating cycles that, in the case of Menaggio hospital, are of lithium bromide type (LiBr), a strongly absorbing salt. In short, these refrigerating machines exploit the natural evaporation of water (solvent) at very low pressure, which occurs at temperatures of some degrees above 0 °C, and the physical-chemical properties of the lithium bromide (solute), to produce refrigerated water without almost using electrical energy. It is however necessary to supply heat at high temperature: when the latter grows, also the efficiency of the refrigerating cycle rises.

What is the solar cooling?
It is a still scarcely diffused technology, which couples thermal solar devices and absorption refrigerating groups. Its main advantage consists in the possibility of exploiting the concomitancy, in the summer period, of the bigger availability of solar energy and the energy demand for cooling. The variability of atmospheric conditions makes the collection of the sun energy discontinuous, therefore these systems are generally equipped with accumulation devices. The solar cooling allows then the best use of the renewable solar source, consequently reducing the consumptions of electrical energy ascribable to standard refrigerating groups, normally entrusted with integration and reserve functions.

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