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Study and comparison of control and regulation systems for solar thermal plants

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Abstract

Solar thermal systems are mainly used for the application of small size in the residential market, with the purpose of producing domestic hot water and, in applications that allow, covering part of heating requirements. This technology is increasingly used in other fields of application through the adoption of largest size systems that are more complicated than residential systems and require a detailed and careful design. Among the different phases of design, there is the study of the best system of management and control; this research aims to develop a help for designers during this choice. The first step of this work has been a commercial search in order to determine the current modes of control of solar thermal systems. After, were made some dynamic simulations using some of the control mode previously defined. The simulations were done with Matlab-Simulink simulation software using a stable and calibrated dynamic model. Simulink is a graphical interface that uses different types of elements (blocks) that allow creating models to simulate a dynamic system; that is, a system that can be represented by a model of differential equations or difference where the independent variable is time. Finally, the control modes were tested in a building energy retrofit.

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1. Solar Energy

Solar energy represent one of the most important renewable source we should use for decrease dependence by fossil fuel.

In the last few years, it assists to an inversion in the use of this energy source; in fact, solar plants are not used to satisfy only a small part of the energy demand but are designed to satisfy most of the demand, while no-renewable systems involved to a lesser extent in the event of need. One of the more important innovation is using the solar energy for cooling demand.

The solar-cooling systems for buildings, in fact, have become a viable alternative to conventional systems since, especially in recent years, the demand for electricity in summer has reached extreme peaks for the excessive use of conventional air conditioners, up to sometimes cause the blackout of the electricity grid. For these same problems, it must think also about how to satisfy the future energy needs of developing countries [1]. The use of solar energy to produce cold becomes winning opportunity, as demonstrated by numerous pilot projects in different European countries [2,3, et other]. The use of solar energy for buildings' cooling demand is an attractive hypothesis, because the period that register the greatest demand for air-conditioning overlaps with the months during which the solar radiation is at its maximum and the days are longer. The air-conditioning systems to solar energy have also the undoubted advantage of using harmless working fluids, such as water or saline solutions. They are environmentally friendly, based on the criteria of efficiency and can be used alone or integrated with traditional air conditioning systems, to improve the air quality in all types of buildings.

Another innovative use of solar energy are SDH plants (Solar District Heating). SDH are plants of high dimension that seek to satisfy the total heat requirement for DHW in summer with solar fractions considerable also in the rest of the year. The major examples are in Northern Europe and in Germany [4] where many studies have shown the convenience of solar thermal plants respect other renewable sources (Fig.1).

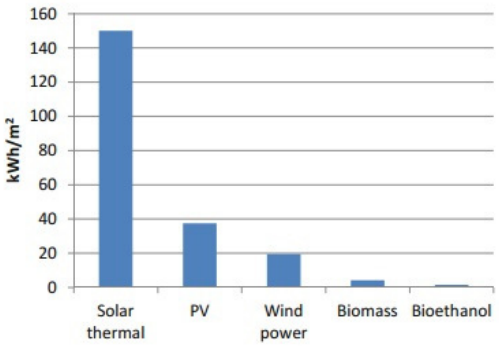

Fig. 1 Annual yield per m² of land used for different renewable energies in Northem Europe [5]

2. Control for solar plants

The controllers used in solar thermal systems are proposed generally in many different shapes and sizes and offer a variety of different options. The most basic controllers just have a differential control, which activates the solar pump when the temperature misured by the sensor on the collector is higher than the temperature of the sensor in the storage tank.

However, with innovations in the fields of pumps and regulation managements is possible to improve the production of the solar system. The aim of this work is to try to quantify this improvement and the resulting increase in annual performance. Obviously almost every controllers will be set up slightly in different way because each system is designed specifically for the single application. The pipe length, for example, between the collector and tank, will determine the most energy efficient setting for the switch of value of the pump if is used a basic regulation. The most important innovation is the possibility to regulate the pumps' speed by the inverter, with which the average