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Watergy project: Towards a rational use of water in greenhouse agriculture and sustainable architecture

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Abstract

Watergy project is funded by the European Community's Vth Framework in its Energy, Environment and Sustainable Development programme. It consists of the development of a humid air solar collector system that follows the principle of a closed two phase thermosyphon. A combination of evaporation and condensation allows to use solar thermal energy in a much more efficient way. The main advantage is not only the reduction of costs in space cooling and heating, but the possibility of water purification, as the system can be fed with low quality water to obtain distilled water. The decentralization of heat and water supply opens the possibility of residential areas where greenhouses fed with low quality water (grey water and brackish water) could be used to produce distilled water as well as heat and fruits. The project contemplates the development of two prototypes: one application for arid climates in Southern Europe with an emphasis on water production in the context of greenhouse horticulture, and another for temperate Central European climate focused on heat and water production for sustainable architecture.

Keywords: Water treatment; Water management; Solar collector; Agriculture; Architecture

1. Introduction

The limited water resources are real challenges for the actual status of intensive greenhouse horticulture as a highly profitable technology of food production in Mediterranean areas. The intensive horticultural production system using greenhouses was shifted from Central to Southern Europe due to the increasing energy prices. The semi arid Mediterranean climate allows for a concept of passive greenhouse with considerably less addi-

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tional energy demand [1]. However, even though the greenhouse itself is a means of saving water (compared with outside growth, greenhouse horticulture demands a third less water consumption [2]), the water scarcity associated with the areas where the greenhouses are developing is a serious handicap for the sustainability of the actual production system.

Although modern technology proposes desalination as a source for this growing demand of water, common technologies are also strongly affected by their large demand for primary energy. Another technological solution is widely discussed: the idea of heat and water recovery from greenhouse air discharge or from the inside of closed greenhouse with the aid of heat exchangers and heat accumulation systems [3]. However, this solution faces with several problems: (i) the amount of energy needed for the transport of hot air to a heat exchanger, requiring forced ventilation; (ii) the reduced efficiency of the heat transfer from air to water due to the little heat capacity of air; (iii) the unwanted shading created on the plants by the heat exchangers, usually placed in the hottest area of the greenhouse, which is the roof zone; and (iv) the low temperature regime established by plant tolerance (usually no more than 35ºC).

The issue of sustainable architecture is a growing one, and energy efficient buildings are being promoted by governments and private organizations. However, although solar energy is slowly being introduced in the energy balance of the buildings with the use of standard solar collectors and even means for heat storage, the aspect of water supply and purification is still subject to centralization and dependent on an existing network.

2. A new concept of solar collector

Project Watergy proposes a new concept of solar collector based on a humid air circuit powered by thermal solar energy [4]. The collector is formed by a greenhouse connected with a solar chimney, inside of which a cooling duct contains an air-to-water heat exchanger connected to a heat accumulator (Fig. 1). The process starts with the heating of the air inside the greenhouse, which rises to the solar tower by natural buoyancy. The evapotranspiration of the plants and soil is added to the air, which becomes humid. Above the greenhouse, removed from the plant area, the rising air is further heated in a secondary solar collector until it reaches the maximum temperature at the top of the solar tower. In this secondary collector, in order to saturate the rising air while it is heating, a humidification system acts as an additional evaporation source. The aim is to have very hot and humid air at the top of the solar tower. Inside the tower, a feedback duct contains a heat exchanger which cools the air. On the surface of the heat exchanger, the cooling of the humid air creates condensation, releasing additional thermal energy and distilled water. The cold and dry air falls back to the greenhouse, where it is heated and humidified starting the cycle again. The final element of the closed system is a solid state fermentation device [5]. Greenhouse plants and fermentation micro-organisms supply each other with oxygen

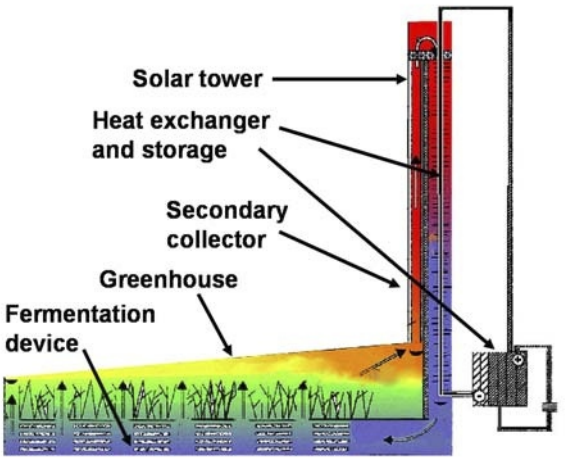

Fig. 1. Scheme of the new humid air solar collector proposed in project Watergy.