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NOVEL STANDALONE SOLAR DRIVEN AGRICULTURE GREENHOUSE DESALINATION SYSTEM: Self Sufficient of Energy and Irrigating Water

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EXTENDED ABSTRACT

Introduction

Egypt's natural water resources are in a critical limiting range and the annual per-capita consumption is now less than 550 m^3 as compared to the UN standard average of 1000 m^3. The water shortage will be worsened after Ethiopian dam is constructed on the Blue Nile (that provides 85% of Egypt's Nile water). Additionally, agriculture is the most water consuming activity in Egypt (70-80%) and worldwide. Most of Egypt's land is desert (near 94%) where saline brackish water is available. Saline water desalination has, therefore, become a strategic alternative water resource to be adopted in Egypt. On the other hand, open field agriculture in such conditions, with mainly dry and hot environment, is not economical with such limited water resource. Therefore, agriculture Greenhouses (GH) presents a suitable alternative for different plants growth for Egypt's desert. With the available high solar energy in Egypt, integration of solar – GH – desalination systems present a real challenge and is the focus of this paper.

This paper presents a novel solar driven agriculture GH with built-in desalination processes. The target is developing, manufacturing, and pilot testing the system in Egypt and the MENA-GCC region. The new proposed integrated system should, therefore, be (i) standalone and grow its energy and irrigation water demand; i.e. be self-sufficient of energy and irrigating water, (ii) has a suitable microclimatic conditions for different plants in order to be a provider of the basic food needs for small community living in remote areas and (iii) a means of creating jobs and business opportunities.

System characteristics

- **Standalone**

The developed system is standalone as it grows its energy and irrigation water demand. Figure 1 illustrates the conceptual configuration of the proposed system, [1]. The system consists of; (i) GH cavity where plants grow, covered by (ii) double layer of transparent material to transfer light to the GH cavity, iii) circulating ventilation air path via a vertical and inclined riser, (iv) Photovoltaic (PV) panels, placed in the air path, that are cooled and help with the natural ventilation air mechanism, and (v) a condenser that is placed at the GH cavity exit to cool the air and partially recover transpiration water from the air.

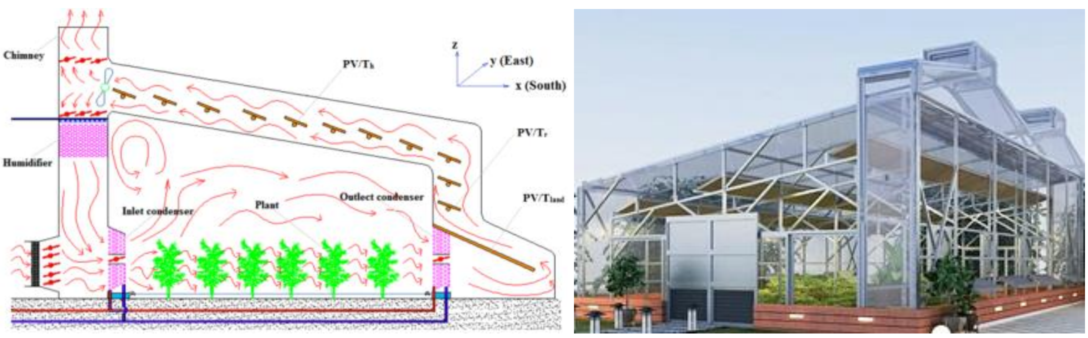

Figure 1. Conceptual configuration of the solar driven greenhouse, 2-D (left [1]) and 3-D (right)

- **Controllable microclimate**

A transient mass and energy balance mathematical model is developed to monitor the heat and mass transfer within the GH components to maintain suitable microclimatic conditions for different plants. The developed model is then used to simulate the GH performance for a typical environmental condition in Zagazig city, Egypt, Figure 2, [1]. On the other hand, a CFD analysis is carried out to monitor the microclimate configuration of the venting air scenarios where the temperature or velocity changes exceed a certain level or for specific environmental conditions (Figure 3) [2].

GH cavity conditions

Power and Water production

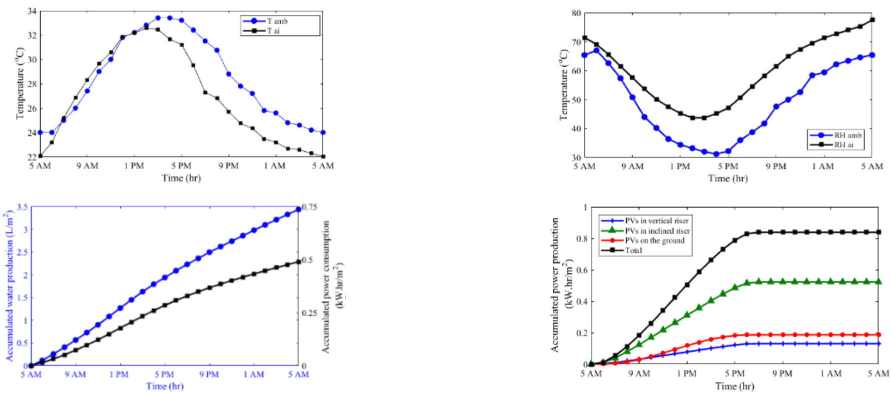

Figure 2. Results for a typical day of maximum radiation in Zagazig, Egypt [1]

Temperature Contours **Velocity Streamlines** **Velocity Vectors**

Open Lower Vent
V=2 m/s
T=310K

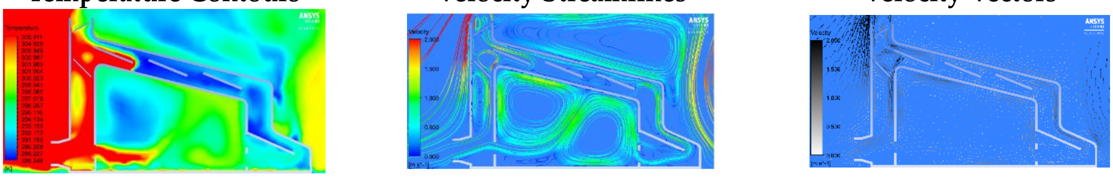

Figure 3: Temperature contours, velocity streamlines, velocity vectors for open lower vent scenarios with the initial conditions of velocity 2 m/s and temperature 310 K [2]

- **Multi-discipline**

The newly developed system is a means of creating jobs and business opportunities and could be a module for a larger integrated complex of water-energy-food nexus to sustain remote communities.

Conclusions

A novel solar driven agriculture GH is developed for arid areas where harsh climate, and saline water is found, to provide suitable environment for plant growth. The developed system uses the extra solar radiation, above the photosynthetic plants needs, to power the GH and to desalinate water for plants irrigation. The developed system can provide controllable microclimate conditions in the GH plants. In addition, it recovers transpiration water via dehumidification process. This system contributes in creating jobs and business opportunities when it applied in commercial scale.

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