Selling hot air: The potential of solar heat for agricultural drying applications

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INTRODUCTION

A surplus of manure from livestock may cause environmental pollution and resource waste if not handled properly. A common step during the treatment process of manure is drying. Solar energy can provide a significant contribution to a reduction on the energy demand for this drying process.

Fig.1: PVT on a farm roof

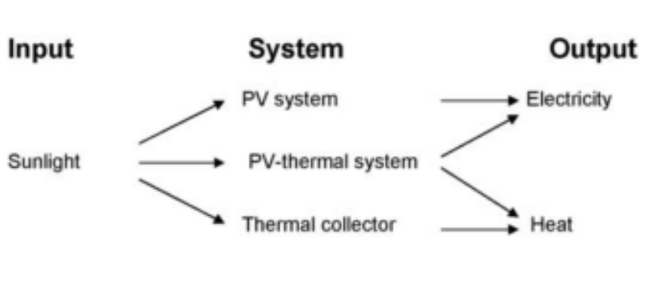

Fig. 2: PVT systems

Currently there are two common systems that utilize the suns energy for human use, the solar photovoltaic (PV) cell, & the solar thermal (T) collector. A photovoltaic thermal (PVT) collector combines these two techniques and delivers electricity and heat, with the solar cells generating the electricity and acting as the absorber for the heat at the same time. See figure 1 and 2.

The organizations SEAC and WUR have developed in cooperation with other industrial partners a low cost PVT-air collector. The main purpose of this new development is to examine if it is possible to use this heated air from a PVT-air system for manure drying purposes.

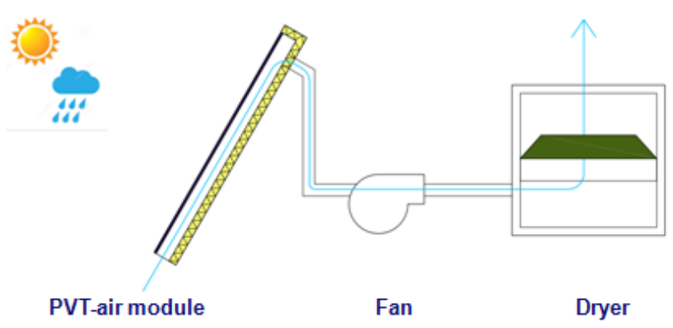

Fig. 3: PVT – air drying system

Fig.4: Photo test setup Sterksel

One of the characteristics of PVT air-heating collectors is the strong dependence of the thermal collector efficiency and PV cell efficiency on the air mass which flows through the collector. The higher the flow rate, the better is the heat transfer from the absorber to the heat transfer medium and the higher the efficiency of the PV cells. However a high flow rate is coupled with a relative low temperature of the air.

OBJECTIVE

The focus of this project will be on assessing the drying capacity of a PVT-air collector. The main research question of this project is:

1. *Is it possible to dry agricultural products with solar heath?*

The challenge during this project is to find a good trade off between the performance requirements of the PV cells, the thermal heat collector and the drying system. Early research concluded that the fan control strategy has a large impact on the heat output. This all lead to the following sub research questions:

1. *What key parameters influence the hot air production?*
2. *What is the required temperature and flow demand of a drying system for agricultural purposes?*
3. *What is the correct balance between high speed & low outgoing air temperature versus low speed & high outgoing air temperature?*
4. *What is the influence of the heat on the performance of the PV cells?*

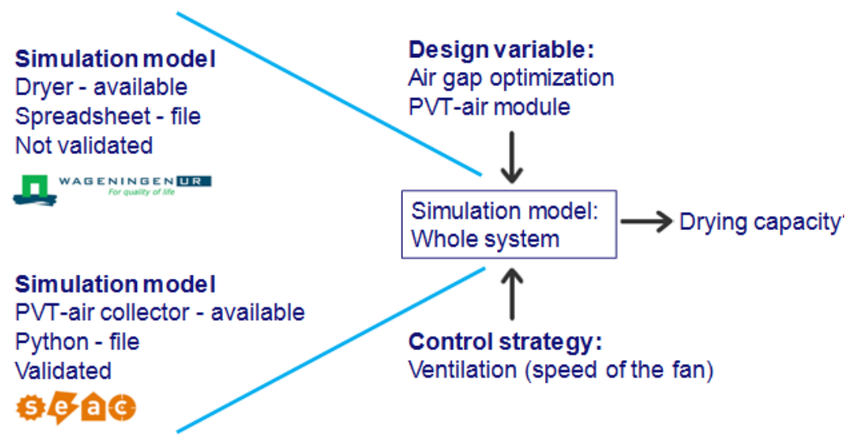

Fig.5: Schematic overview of the simulation study.

METHOD

The project starts with analyzing the available simulation models. These are the SEAC thermal model (Python-based) and the WUR manure drying model (Excel-based). After this step, these two models will be combined in a single Python model (figure 5). The simulation results of this model will be compared and valditated with measured data of a test setup in Sterksel (figure 4).

Figure 1 + 4: A.M. Bosch (2014) - Master project: A thermal model for photovoltaic-thermal air collectors and a case study

Figure 2: Hasan, M.A, & Sumathy, K. (2010). Photovoltaic thermal module concepts and their performance analysis