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Feasibility Analysis of Solar Wall Application in Seed Maize Drying

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Abstract: Nowadays the energy issue in agricultural production is being aggravated. One of the most energy-intensive production stages is drying. Many companies are looking towards highly efficient heating solutions which can be applied with established renewable technologies instead of fossil fuels. One of the basic problems in seed maize drying firm is the reduction of energy demand for hot air supply to drying room heating. In this study, in order to use the LPG for seed maize drying, the possibilities of using solar wall application were examined. The results show that hot air supply with this method is applicable. It is estimated that daytime drying energy savings varies between 33.8- 82.2% in August, 27.7-67.2% in September.

Keywords: Solar Wall, Energy Saving, Seed Maize Drying.

INTRODUCTION

One of the basic problems in different aspects of buildings is the reduction of energy demand for space heating (Lenik and Wójcicka-Migasiuk, 2010). We need to achieve good ventilation effect and do not cause the waste of energy (Wang et al., 2013). Although the energy uses efficiently, rising of fuel prices is the problem and predicted to increase even more. Thus, the usage of renewable energy is required. Solar energy is one of these resources, can be used for different purposes.

Among all the technology of making use of solar energy, the most notable one is the solar wall technology is an unglazed solar air heating system that uses solar energy as fuel to heat or ventilate indoor spaces in new or retrofit construction. Nowadays, it is widely used in commercial, industrial, manufacturing complexes, multi residential and agricultural farms buildings. System design specifications depend on the application, location and climate (Jin and Jialin, 2011).

Solar wall technology has been successfully used for many agricultural applications such as coffee drying, walnut drying, jujube fruit drying, herb drying and chicken barns ventilation. In addition, there are several energy researches such as energy simulation analysis of solar wall heating and ventilation system in severe cold region (Jin and Jialin, 2011), analysis of the solar wall heat transfer and energy saving of residential ventilation (Wang et al., 2013), the solar wall in the Italian climates (Stazi et al., 2008), feasibility and energy recovery of a solar wall in pig nursery (Godbout et al., 2004). However, the drying process of seed maize has not been investigated in literature. This article discusses the feasibility analysis of solar wall application in seed maize drying firm, and helps to decrease pressure on seed businesses to become more proficient both financially and environmentally holistic heating solutions which can be combined with established renewable technologies as part of their sustainable building strategy and drive towards energy efficiency and reduced CO_2 emissions.

MATERIAL AND METHODS

1. Seed Maize Drying

Seed maize dried with cob at maximum temperature of 111°F (44°C) and then separation of maize kernels from the cobs is made by shelling machines. (Yağcıoğlu, 1999). A normal drying season in Turkey consists of two months from the beginning of August to end of September. The seed maize is dried to 14% moisture content (Doymaz and Pala, 2003). Drying method is given in Figure 1.

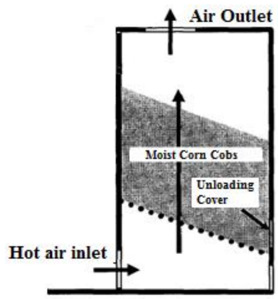

Figure 1. Sectional view of the drying chamber (Şehirali, 1997)

2. Drying chamber

Drying chamber consists from 4 rooms. Each drying room dimensions are 5 x 5 x 6.4 m. and can contain around 30 tons of corncobs. Hot air production process works with burning of LPG fuels via by burners. Combustion of this fuel, even perfect, generates an important amount of carbon dioxide. Technical drawing of building is given in Figure 2.

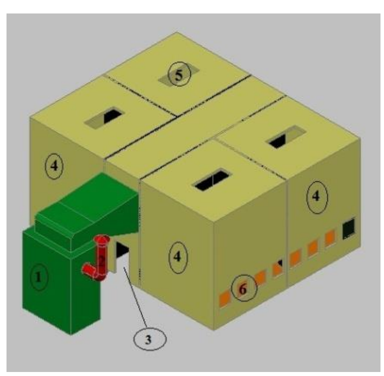

Figure 2. Technical drawing of building; 1.Burner, 2.Chimney, 3.Entrance Door, 4.Drying Rooms, 5. Loading Cover, 6. Unloading Cover

3. Location

Karacabey is a town in the province of Bursa, south of the Marmara Region (Figure 3). Average altitude is 24 m. According to 59-year observation of meteorological data, annual average temperature in August and September is 23.3 °C and 18.7 °C, respectively (MGM, 2014). Global radiation values are 5.36 kWh/m^2-day in August and 4.28 kWh/m^2-day in September (EIE, 2014).

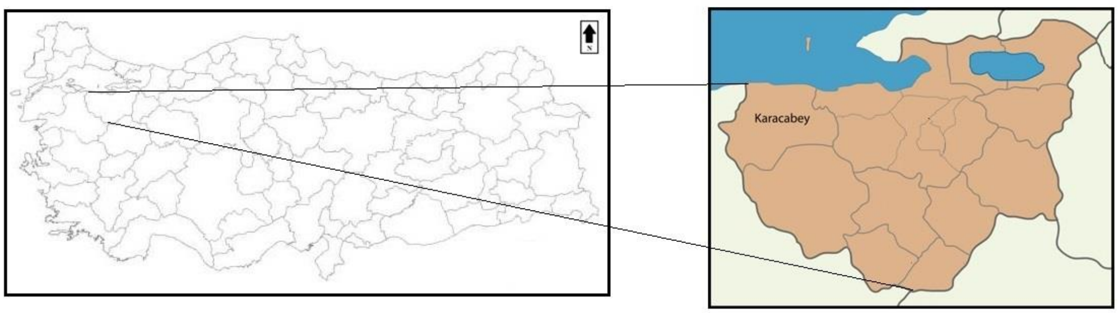

Figure 3. Location of study area

4. Solar Wall Application

Solar wall systems are installed as an additional skin on a building. System consists of two parts: a solar collector mounted on the wall or roof of building facing and a fan and air distribution system installed inside the building. When the sun warms the surface of the metal Solar wall collector, air is drawn through small holes in the dark colored solar collector plate and is warmed as it passes over and through the plate. The solar heated air is then distributed throughout the building via the conventional ventilation system or dedicated fans and ducting. Figure 4 presents a schematic of both solar wall systems (Gong et al., 2012; Solarwall, 2014).

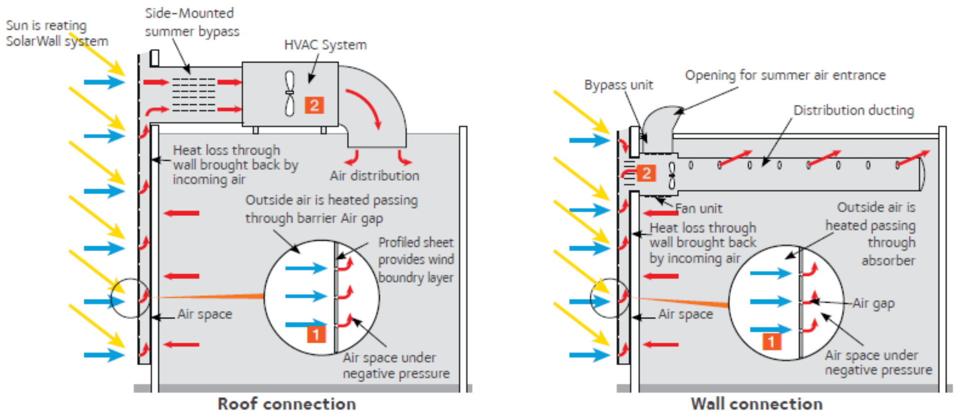

Figure 4. Wall mounted and roof mounted solar wall systems

Another factor of affecting the efficiency of solar wall is wind speed, except radiation intensity. In this context, the classification of minimal, low and medium wind speed is 0-4m/s, 4-5 m/s and 5-7 m/s, respectively (Eremia and Shahidehpour, 2013). Air temperature increase due to wind and irradiation is shown in the Figure 5.

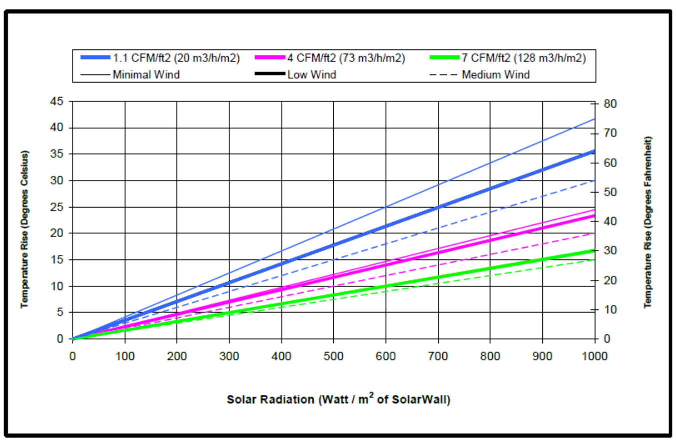

Figure 5. Air Temperature Rise (Solarwall, 2014).

RESULTS

Within the firm's drying room, 29.760 kg of corn cobs dried at 44°C. This process took 56 hours. Initial product moisture was 19.75% and drying process was continued until 12%. About 6.060 kg water was removed by drying the corn cobs. 54.690m^3 natural gas is burned for this process.

Instead of using fossil fuels, on a sunny day this air will be heated with solar wall in anywhere from 15-40°C above ambient, making it ideally suited for many agricultural crop drying applications. Especially, low temperature requirement is ideally suited for the use of the solar wall technology such as seed maize drying.

In this study area, the average incident radiation in the day time was carried out is about 450W / m^2 during the 12^{th}-14^{th} September 2012 experiments. It is estimated that hot air production can be between 30.3 - 40.3°C in August and 25.7- 35.7 °C in September, depends on daily wind speed. In this way, daytime drying energy savings varies between 33.8- 82.2% in August, 27.7-67.2% in September.

CONCLUSION

Instead of systems based on the use of fossil fuels, renewable energy source systems are very valuable in terms of sustainable agriculture. A Solar wall system is easily retrofit to existing active drying processes that use fuels such as LPG heat, and represents an economic and environmental respectful energy source, allowing, among others things, to reduce CO_2 emissions. For the clean and non-operating costs production should be supported with the use of such systems.

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