

**Title:** Assessment of the Energy and Water Use Efficiencies and Economic Viability for a Solar-Powered Fan-Chiller-Tube-Bank (FCTB) Cooling System in Greenhouse Agriculture.

Ohood Al-Ghadani, Talal Al-Shukaili, Hemantha Jayasuriya, Pankaj Pathare, Ahmed Al-Busaidi.

Department of Soils, Water and Agricultural Engineering, Sultan Qaboos University, Oman.

### **Abstract**

The Fan-Pad cooling system is the most commonly used in the greenhouse in arid countries like Oman. However, its intensive water and energy consumption challenges its efficient use under these harsh environmental conditions. This study aims to evaluate the energy use efficiency (EUE), water use efficiency (WUE) of a greenhouse developed with the new concept of an on-grid solar-powered, fan-chiller-tube-bank (FCTB) cooling system using pot-grown okra. In addition to conducting cost-benefit and cash flow analyses. With an on-grid solar system, the income comes from the crop and the sale of excess electricity to the grid. The growth setup was developed with a Quonset side-walled single-span greenhouse, pot-based okra cultivation, and an automatic scheduled irrigation system. The water consumption and electricity consumption were recorded, and the excess energy supplied to the electricity grid was also estimated. In the efficiency assessment, total water use efficiency (WUE), irrigation water use efficiency (IWUE), cooling water use efficiency (CWUE), and energy-use efficiency (EUE) were calculated. The results showed that the greenhouse equipped with solar-powered FCTB improved EUE, with a value of 1.16 and a positive net energy of 163.87 MJ/m<sup>2</sup>. The WUE, IWUE, and CWUE were 0.91 kg/m<sup>3</sup>, 2.07 kg/m<sup>3</sup>, and 1.63 kg/m<sup>3</sup>, respectively. In addition, the economic performance indicated that growing okra with a solar-powered FCTB cooling system was economically unfeasible with a cost-to-benefit ratio less than one (0.99). The values of the internal rate of return (IRR) and net present value (NPV) of cucumber (IRR40%, NPV 2.03 ×10<sup>4</sup> USD) and cherry tomatoes (IRR 33%, NPV 1.89 ×10<sup>4</sup> USD) indicated the profitability of these crops with this greenhouse. Furthermore, using solar energy in the FCTB cooling system improved greenhouse efficiencies, economic viability, profitability, and sustainability.

### **Keywords**

Greenhouse cultivation, fan-chiller-tube-bank cooling system, energy use efficiency, water use efficiency, cost analysis.