# Chapter 24
# 3D Scanning and Simulation of a Hybrid Refrigerator Using Photovoltaic Energy

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## ABSTRACT

*In this chapter, a methodology that starts from the measurement and recording of real prototype geometries up to simulations to evaluate parameters, improvements, or performance under various conditions is proposed. Here a case study of a solar powered refrigerator with storage capacity for 50 kg of fruit is presented. The refrigerator comprises two systems: vapor-compression and Peltier. The methodology consisted in acquiring by a 3D laser scanner or coordinate measuring machine (CMM) and in some small complex items using a 3D photogrammetry scanner. These data were transferred first as a CAD or SolidWorks® geometry and subsequently transferred to domains geometry useful for ANSYS or COMSOL*

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*simulation software. These models with high-resolution brings the simulations closer to real prototypes. As a source of direct information from the prototypes, thermal images obtained using a thermographic camera were taken. Also, wireless sensors were installed for temperature and humidity monitoring. The analyses of the energy efficiencies of both prototypes were performed.*

## INTRODUCTION

In this chapter, a methodology that starts with the measurement and recording of real prototype geometries up to simulations to evaluate parameters, improvements or performance under various conditions is proposed. Here it is presented a case study of a solar powered refrigerator with storage capacity for 50 kg of fruit. The refrigerator comprises two systems, vapor-compression and Peltier. The methodology consisted in acquiring by a 3D laser scanner or Coordinate Measuring Machine (CMM) and in some small complex items using a 3D photogrammetry scanner (James, 2017; Ozdarici-Ok, 2015). These data were transferred first as a CAD or SolidWorks® geometry and subsequently transferred to domains geometry useful for ANSYS or COMSOL simulation software. These models with high-resolution brings the simulations closer to real prototypes. As a source of direct information from the prototypes, thermal images obtained using a thermographic camera were taken. Also, wireless sensors were installed for temperature and humidity monitoring. The analyses of the energy efficiencies of both prototypes were performed. The idea of presenting this methodology is to demonstrate that it is possible to apply it in various prototypes regardless of sizes, geometries or whether they are or not solar powered.

The work seeks to develop a hybrid cooling system based on a system of traditional compression system and a Peltier cooling system. The construction or production of this system is focused on being able to assist the agribusiness sector that is away from the public electric network, directly in the crop areas, proposing that this system will be powered completely by photovoltaic modules and in turn, be able to innovate with the cooling systems adaptations.

The starting point was a commercial compression system, to build or make an approach of the required refrigerator with a capacity of 50 kilograms. The material used in the Peltier cooling system consisted of: four Peltier modules of 50 W, eight heat sinks and eight fans that assist with the distribution of heat within the refrigerator.

The following steps were the elaboration of the construction drawings, drilling and placing of the Peltier systems, in a distribution geometry designed in the SolidWorks® software. All the parts were put in place both physical and mechanical. Some of them were affected during the modification process. The geometry was acquired and exported for its analysis in a virtual simulation module of finite element (Work Bench ANSYS), to obtain a validation or improvement of the system with the efficiency of space and location, considering the fluid dynamics and thermodynamics.

A general scanning was conducted for a commercial refrigerator with a laser system (ZX 800 Corp) and, for the smaller parts, with a system of photogrammetry (PicoScan Pro). The scannings were conducted using these devices for the development of a virtual 3D modeling. In this process, a polygonal mesh was applied to the virtual model initially constituted only of a point cloud (Bici, 2014), which is transformed into a file compatible with the simulation software.

Once that the process with the commercial refrigerator model reaches the simulation stage, the methodology is applicable to the construction and adaptation of the Peltier system using as a guide the electrical drawings previously made. To achieve a relationship between the Peltier system and the compression system uses a temperature sensor programmed to monitor the functioning of these systems on the basis of specific conditions known during the simulation process.