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Variable-Refrigerant-Flow Cooling-Systems Performance at Different Operation-Pressures and Types-of-Refrigerants

Roba Saab, Mohamed I. Hassan Ali*

Mechanical and Materials Engineering, Masdar Institute for Science and Technology P.O. Box 54224, Abu Dhabi , UAE

Abstract

This paper aims to study the performance of the Variable Refrigerant Flow (VRF) system under various conditions in hot and humid climates such as Abu Dhabi, in the United Arab Emirates. The model is built on Engineering Equation Solver (EES) with input data obtained from the specifications of the VRF units used, and the design requirements from the Masdar City Eco-Villa for which the model is done. A number of parametric studies are done on the VRF cycle model, such as, the variation of low and high pressures, in addition to, the variation of the type of working fluid used. Results have shown that the coefficient of performance (COP) of the cooling cycle is highly dependent on the evaporator and condenser pressures, as well as, the type of refrigerant used as working fluid. Finally, by evaluating the effect of each parameter on the COP of the system, the expected amount of energy savings can be increased.

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Keywords: VRF; EES; air-conditioning; Eco-Villa; energy modelling; refrigerants

1. Introduction

VRF is an advanced air-conditioning technology which has been in the market for tens of years, but little research models were carried out to represent the system. In fact, modelling such systems is complex due to the variability nature of most of the components in the cycle, and many studies attempt to do experimental analysis on such systems instead.

* Corresponding author. Tel.: +971-52-9192514.
E-mail address: miali@masdar.ac.ae

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Nomenclature

COP	coefficient of performance
h	specific enthalpy of refrigerant

1.1. Overview

Due to the hot and humid weather of the UAE, the portion of electricity in buildings consumed for air conditioning exceeds 50% of the total energy consumption [1]. Therefore, it is of high interest to researchers in the area to improve the efficiency of air conditioning systems in an attempt to reduce the total energy consumption. Many studies have shown that VRF systems tend to consume less energy when compared to other systems, making them suitable equipment to be installed in the UAE. However, only few studies have been conducted on this type of air-conditioners in the Gulf region in general, and the UAE in particular. Therefore, it is crucial to conduct studies on this system in the UAE in order to well predict the performance of VRF in such climate. Figure 1 shows the breakdown of residential electricity consumption in the UAE per end user [2].

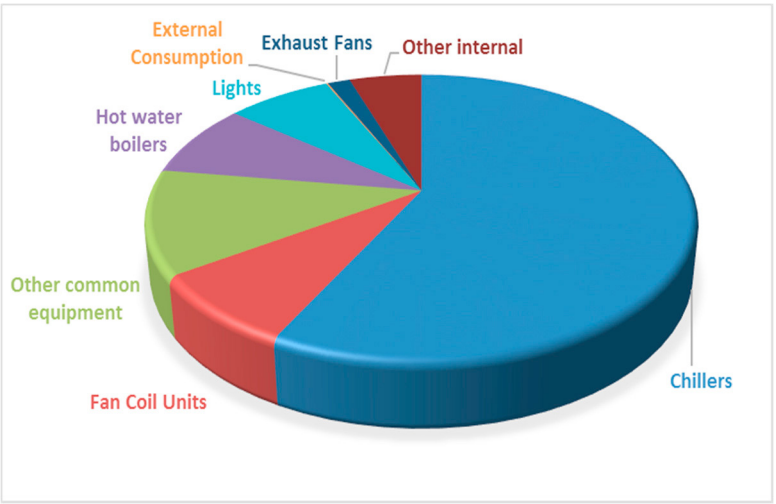

Fig. 1. Breakdown of residential electricity consumption in UAE [2].

Figure 1 clearly indicates that air-conditioning components such as fan coil units and chillers together make up more than 60 % of the electricity consumption in the buildings in UAE.

Variable refrigerant flow (VRF) is an HVAC system that includes single or multi compressors and a number of indoor evaporators connected to a single condenser [3]. This feature of VRF enables each conditioned room to have individual temperature control to ensure thermal comfort in the building, and at the same time saving energy.

As it has been demonstrated by one supplier, the variable compressor speed enables the load to gradually reach its maximum set point. On the other hand, conventional cooling systems' compressors are running at single speed which cause sudden increase in the load to reach its maximum set point. This versatile configuration in addition to the multiple evaporator loads setup are the main core enhancement in the VRF system towards power saving. This power saving feature is the main advantage which VRF system has as compared to other air conditioning systems. In fact, by using VRF systems in the UAE, where applicable, the energy saved would cut down the total electricity consumption and thus, the cost associated with it. In turn, this approach will have significant impact on sustaining the environment, complying with the UAE's vision of 2021.