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ScienceDirect

Energy Procedia 81 (2015) 100 – 107

Energy Procedia

69th Conference of the Italian Thermal Engineering Association, ATI 2014

Climate influence on seasonal performances of air-to-water heat pumps for heating

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Abstract

A mathematical model for the evaluation of the seasonal performances of electric air-to-water heat pumps for heating is used to analyze the efficiency of on-off heat pumps, multi-compressor heat pumps and heat pumps with inverter compressor, integrated by electric heaters as back-up system, in the service of several buildings located in different Italian climates.
The paper points out the importance of a good dimensioning of the heat pump as a function of the building energy signature and of the climate of the city where the building is placed, in order to enhance the system seasonal efficiency.

Peer-review under responsibility of the Scientific Committee of ATI 2014
Keywords: air-to-water heat pumps; SCOP; seasonal performances; bin-method; bivalent temperature

1. Introduction

Nowadays the reduction of buildings energy needs is strongly required by the European Commission and heat pumps can help to achieve European targets because aero-thermal, geothermal and hydrothermal energy is recognized as renewable energy.

Air-to-water heat pumps are particularly suitable for the replacement of heat generators in energy retrofit of buildings, as air source is wherever available and they are easy to install and relatively cheap. Nevertheless, the performances of air-to-water heat pumps are strongly dependent on the external air temperature, which continuously changes in time during the heating season. As a consequence, the good sizing of the heat pump, which is crucial in order to obtain good seasonal performances, takes into account not only the building loads, but also the climate of

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Peer-review under responsibility of the Scientific Committee of ATI 2014
doi:10.1016/j.egypro.2015.12.064

the location where the building is located and the kind of control system of the device, which is responsible of the heat pump performances at partial loads. In fact, heat pumps work at nominal conditions only for a limited part of the heating season and authors like Bettanini et al. [1] and Henderson et al. [2] demonstrated as heat pumps seasonal performances are strongly influenced by the values assumed by the Coefficient Of Performance (*COP*) at partial loads.

In order to take into account the variability of the outside climate, the evaluation of air-source heat pumps seasonal efficiency (*SCOP*) is usually carried out through the bin-method. Many researchers have proposed calculation methods for the evaluation of heat pumps seasonal performances [3-7] and very recently [8] a simple mathematical model for the determination of the *SCOP* of building heating systems based on electric air-to-water heat pumps integrated by electric heaters as back-up systems is presented by taking into account different kinds of electric heat pumps, like mono-compressor, multi-compressor and inverter-driven heat pumps. The model presented in [8] utilizes the bin-method and it is derived from the European standard EN 14825 [9] and the Italian standard UNI/TS 11300-4 [10].

In this paper the model described in [8] is used to investigate the influence of the outside climate on the seasonal performances of different kinds of heat pumps coupled with different buildings. The results obtained point out the importance of the adoption of appropriate sizing rules for the heat pump in relation to the thermal characteristics of the building, the climate profile of the location, and the kind of heat pump regulation system.

2. Bin-method

For the evaluation of the heat pumps seasonal performances the European standard EN 14825 and the Italian standard UNI/TS 11300-4 suggest to model the outdoor climate by means of the bin-method. A bin represents the number of hours in which the external air temperature has a value within a fixed interval centered on an integer value of temperature and 1 K wide.

The standard EN 14825 splits Europe in three winter climates (Colder, Average and Warmer) and directly provides the bin trends for the heating season of each climate. The standard UNI/TS 11300-4, on the contrary, presents a calculation method, based on a normal external air temperature distribution, which allows to evaluate the bin profile of a specific location in Italy. The input data for this method are the local monthly average outdoor air temperature, outdoor design temperature (T_{des}) and monthly average daily solar radiation on horizontal plane (data available for Italy from the standards UNI 10349 [11] and UNI EN 12831 [12]).

The bin-method defined by the UNI/TS 11300-4 is here used to determine the bin distribution for the heating season of three different Italian cities: Brescia (45.32°N, 10.12°E), Florence (43.41°N, 11.15°E) and Trapani (38.01°N, 12.32°E). The conventional heating season is from October 15th to April 15th for Brescia, from November 1st to April 15th for Florence and from December 1st to March 31st for Trapani. The bin profiles obtained for these three Italian cities are shown in Fig. 1.

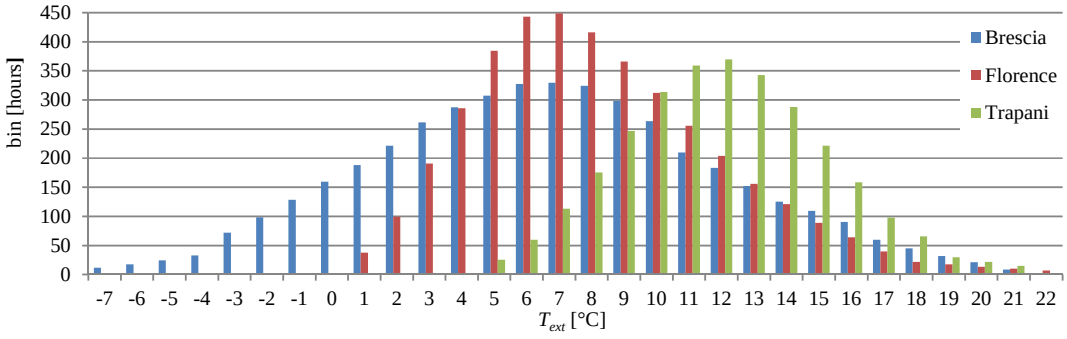

Fig. 1. Bin distribution for the heating season in Brescia, Florence and Trapani (Italy).