Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 133 (2017) 183–194

Energy Procedia

www.elsevier.com/locate/procedia

Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area, 12-13 May 2017, Matera, Italy

Ground source heat pump systems in historical buildings: two Italian case studies

Giuseppe Emmi[a,*], Angelo Zarrella[a], Michele De Carli[a], Stefano Moretto[a], Antonio Galgaro[b], Matteo Cultrera[b], Maria Di Tuccio[c], Adriana Bernardi[c]

[a]*Department of Industrial Engineering - Applied Physics Section, University of Padova, Via Venezia, 1, 35131, Padova, Italy*
[b]*Department of Geoscience, University of Padova, Via Gradenigo 6, 35131 Padova, Italy*
[c] *CNR-ISAC, Corso Stati Uniti 4, 35127 Padova, Italy*

Abstract

Reducing the energy demand of buildings has become one of the key points of the European Union. The issue related to the air conditioning of old and historical buildings is nowadays one of the most important field of operation for the primary energy saving and, at the same time, for the reduction of the CO_2 emission. The recent development of heat pump able to rise the supply of high temperature at the condenser side makes this technology suitable for the application also in historical buildings that are characterized by low thermal insulation and high thermal capacitance. In this context, the ground source heat pump systems can be used for both heating and cooling. The aim of this work is to analyze the thermal behavior of two historical buildings located in Italy, in Venice and Florence respectively. Detailed computer simulations of the buildings have been carried out by means of a transient calculation tool TRNSYS. Energy simulations of GSHP systems have been performed and a comparison with a common plant system using a gas boiler for heating and air-to-water chiller for cooling has been carried out.

Peer-review under responsibility of the scientific committee of the Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area

Keywords: historical buildings, case study, geothermal heat pump, BHEs, renewable energies.

* Corresponding author. Tel.: +39-049-827-6879; fax: +39-049-827-6896.
E-mail address: giuseppe.emmi@unipd.it

1876-6102
Peer-review under responsibility of the scientific committee of the Climamed 2017 – Mediterranean Conference of HVAC; Historical buildings retrofit in the Mediterranean area
10.1016/j.egypro.2017.09.383

Nomenclature

COP	Coefficient of performance of the heat pump
EER	Energy efficiency ratio of the heat pump
SCOP	Seasonal coefficient of performance of the heat pump
SEER	Seasonal energy efficiency ratio of the heat pump

1. Introduction

The use of ground source heat pump (GSHP) systems is one of the most interesting solutions for heating and cooling of the buildings [1]. In recent years, the heat pump technology is gaining new interest in the market due to the new laws and regulations which include this technology as one able to exploit renewable energy sources, in addition to the already acknowledged. In particular, the use of low enthalpy geothermal energy as heat source/sink for the heat pump looks very promising if compared to the more common air-to-water heat pump and it can give an opportunity to achieve significant energy and at the same time economic benefits if well applied [2].

In literature, many studies identify GSHP systems as the most important ones among the most efficient energy technologies for HVAC (Heating, Ventilation and Air Conditioning). GSHPs are divided into three main groups based on the use of ground water from wells, surface water or directly coupled with the ground by the use of ground heat exchangers [3].

The use of water usually involves low investment costs and no ground surface area is required for the installation. The result of ground water from wells is normally good in terms of energy performances because of a constant temperature level of the source/sink during the year, but often its wide application is not allowed because of the local regulation. Normally, systems with great heat pump capacity are coupled with open loop systems where water is pumped from the surface aquifers through a heat exchanger and reinjected at some distance from the intake point. When the use of subsoil or surface water is not possible, ground heat exchangers, called Borehole Heat Exchangers (BHEs), can be used. This type of thermal source/sink is however less efficiency then the use of water because an intermediate heat exchange between the ground and a secondary fluid (usually a mixture of water and antifreeze) is involved. The undisturbed ground temperature is about the mean yearly temperature of the location with a geothermal gradient of about 3 °C for each 100 m of depth. It can sometimes happen that the temperature of the subsoil is higher especially in areas with anomalous gradient of temperature [4, 5]. In such a case the geothermal system can be used only for heating and not for cooling. However, in some cases the BHEs can be connected directly with heating system bypassing the heat pump, especially when the building is heated with radiant systems.

Furthermore, when referring to Mediterranean cities, the relevant cooling needs must be taken into account. As a matter of fact, the heat rejected into the ground, especially in the case of highly insulated buildings, might imply, on the long term, temperature drifts of the soil, thus resulting in reduced cooling efficiencies. In this field, for example Urchueguía et al. [6], report an experimental assessment of GSHP performance in typical Mediterranean coastal climate. The analysis contains a comparison between GSHP systems and air-water heat pumps involving the presence of a specially optimized water–water heat pump using propane as a refrigerant fluid.

2. Method and case studies

This work has been divided into three main steps. The first one is the collection of the required building data for each case study in order to define the energy model of the buildings. The second part of the work is the development of the energy model of the buildings in the simulation tool. In this phase, several computer simulations have been carried out in order to evaluate the heating and cooling peak load and energy demand of the buildings using different hypotheses of managing of the air-conditioning systems. In the last part of the study, the design of the BHEs field, the definition of the properties of the heat pump and the electrical energy demand of the heat pump have been evaluated.