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ScienceDirect

Energy Procedia 45 (2014) 415 – 423

Energy Procedia

68th Conference of the Italian Thermal Machines Engineering Association, ATI2013

Parametric performance analysis of Renewable Energy Sources HVAC systems for buildings

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Abstract

The indoor climate control of buildings represents today the highest percentage of energy consumption in European Union. Hence the evaluation of the best performing HVAC system is a strategic target for both energy consumption and greenhouse gas emissions reduction.

This paper presents a deep analysis of the performance of Renewable Energy Sources HVAC systems for buildings. The technologies considered are biomass boiler, aerothermal, geothermal and absorption heat pumps.

The proposed method estimates all the parameters according to the theory of the "big is better". For each parameter a function has been defined to evaluate how much the performance of each technology depends from it. The analysis take in account also the environment in which each technology operates.

The result is a set of dimensionless parameters, through which it is possible to extrapolate the assessments of performance. It can include both cost-effectiveness and feasibility of a given technology and the contribution to the achievement of European objectives to 2020.

Selection and peer-review under responsibility of ATI NAZIONALE

Keywords: HVAC systems, Renewable Energy Sources, Parametric Analysis.

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1876-6102
Selection and peer-review under responsibility of ATI NAZIONALE
doi:10.1016/j.egypro.2014.01.045

Nomenclature

C_{tot}	overall cost per kWh of useful energy produced
C_0	cost of installation per kWh of useful energy produced
C_i	primary energy consumptions cost per kWh of useful energy produced
C_m	maintenance cost per kWh of useful energy produced
C_{CO2}	cost impact of CO_2 emissions per kWh of useful energy produced
$C_0^*(P)$	installation cost in function of installed power
P	installed power of HVAC plant
$c^*(P)$	consumption of HVAC plant per kWh of useful energy produced and in function of installed power
$hours_{U.L.}$	hours of useful life
$€_u$	cost of fuel or electricity per unit of consumption
$\Delta\eta$ (E.T.)	variation in performance in function of external temperature
kg_{CO2}	mass of CO_2 emitted
$€kg_{.CO2}$	cost per kg of CO_2 emitted
$\%_{(CO2\text{-}f)}$	percentage of CO_2 in the exhaust flow of absorption heat pumps
$\dot{m}_f$	exhaust flow of absorption heat pumps

1. Introduction

A residential building has to be an healthy place where to find the best climate condition. This requirement often involves big energy consumption and high cost for the installations.

The graph in Figure 1 shows how civil applications have the greatest percentage of primary energy consumption in Europe [1]. The first column shows the percentage distribution of primary energy in individual sectors, where the highest percentage belongs to the civilian sector. This sector is mainly composed of buildings used for domestic purposes, where the end-use of energy is mainly dedicated to conditioning in both winter and summer.

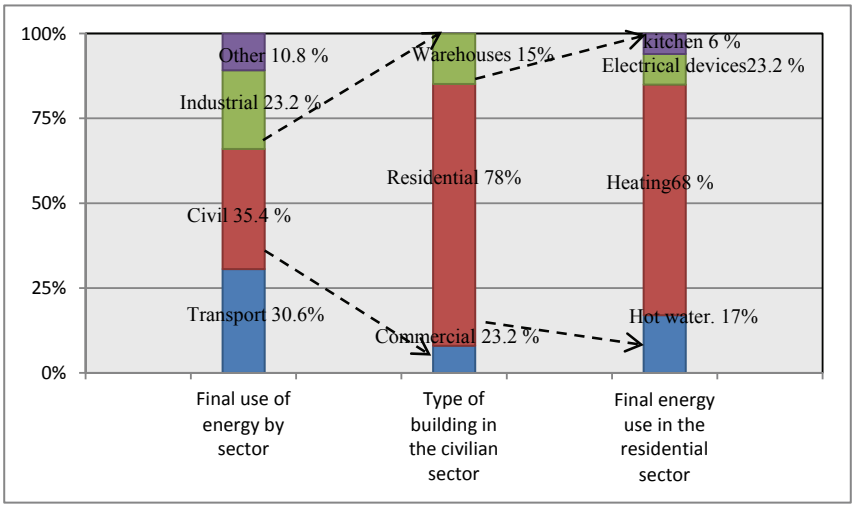

Fig. 1 Primary energy sharing in civil applications in Europe (2012) [1].

This result depends on several factors (e.g. inadequate building envelope or obsolete installations) which in some cases can represent the major barrier to the attainment of optimal indoor climate comfort coupled with the environmental protection. At this purpose, Renewable Energy Sources (RES) HVAC systems pursue well these needs, but often their characteristics are not fully suitable. This consideration involves a careful study, that will try