



Transilvania
University
of Brasov

HABILITATION THESIS

SUMMARY

Title: Energy mixes with high degree of coverage from renewable sources of the thermal energy demand in the built environment

Domain: Mechanical Engineering

Author: Assoc. Prof. PhD Eng. MOLDOVAN Macedon Dumitru

Transilvania University of Brasov

BRASOV, 2024

(A) Summary

The habilitation thesis *Energy mixes with high degree of coverage from renewable sources of the thermal energy demand in the built environment* is in line with the global, European, national, regional and local priorities combating climate change generated by the use of fossil fuels in human activities.

The habilitation thesis presents the didactic and scientific achievements of the author in the period after the conferment of the title of Doctor of Mechanical Engineering (19.12.2012), during his activity as Lecturer (2013-2017), Assistant Professor (2017 - present) and member of the Renewable Energy Systems and Recycling Research Center (2009 - present), all within the Faculty of Product Design and Environment at Transilvania University of Brasov, Romania.

The first part of the habilitation thesis (B-i) summarizes the author's scientific and professional achievements in the field of renewable energy systems implemented in the built environment. This first part is structured in four chapters briefly presented below.

In the first chapter, the main aspects related to the energy mixes used to obtain thermal energy from renewable sources are described. The global and regional evolution of primary energy consumption and the share of primary energy sources are presented and discussed. Their close correlation with the increased number of inhabitants, greenhouse gas emissions and air temperature is highlighted. Final energy consumption and associated greenhouse gas emissions are broken down by activity sector (buildings, industry, transport and others) highlighting the need to take energy efficiency measures and increase the degree of energy use from renewable sources in the built environment. The main measures taken to date, globally and regionally, are presented, starting with the Kyoto Protocol (1997) and ending with the European Green Deal (2019). In this context, an algorithm developed by the author for the design of renewable energy system mixes is presented with examples of its application for several buildings of Transilvania University of Brasov (Solar House, Research and Development Institute of Transilvania University of Brasov) and from outside it (residential communities and agricultural greenhouses).

In the second chapter, the results obtained in the field of increasing the amount of thermal energy produced by solar thermal systems are presented. Concerns to increase this degree of coverage began as early as 2013 and focused on three directions:

- the use of solar thermal collector orientation systems (both to increase the amount of the received solar energy and to protect them from overheating)

- the choice of the type of solar thermal collector for a specific implementation location (from the point of view of the conversion efficiency depending on the temperature difference between the average operating temperature of the solar thermal collector and the ambient temperature)

- the development of novel solar thermal collectors of unconventional shapes and colors to increase the architectural acceptance of solar thermal facades (triangular and trapezoidal solar thermal collectors, with red, green, orange absorbers etc.).

In the third chapter, the results obtained in the field of increasing the amount of thermal energy produced by geothermal systems with ground-water heat pumps are described. Unlike solar thermal systems, which are largely influenced by the variability of solar energy, geothermal systems with heat pumps have the advantage of the permanent availability of geothermal energy that is not influenced by the day-night alternation nor by the change of seasons, a fact for which it can be considered as a base energy source that does not require an auxiliary source. The main types of heat pump-based systems and the main types of geothermal heat exchangers are described. The operation of a heat pump heating system with a vertical geothermal heat exchanger is detailed. Experimental results are presented for different operating modes of the heat pump.

In the fourth chapter are presented the results obtained in the field of increasing the amount of electricity produced by photovoltaic systems to supply the systems installed in a building for the production of thermal energy from renewable sources. Electricity consumption is reduced in the case of solar thermal systems, but becomes significant in the case of geothermal systems. Thus, the building's electricity consumption increases, and it is necessary to implement solutions to increase the amount of electricity produced by photovoltaic systems. Some examples are presented regarding the solutions identified for the Solar House and the Research and Development Institute of Transilvania University of Brasov.

In the second part of the habilitation thesis (B-ii) the future research directions synthesized in *the career development and evolution plans* are formulated. The competences acquired by completing, within the Transilvania University of Brasov, the doctoral and postdoctoral university studies in the field of Mechanical Engineering, the master's and bachelor's university studies in the field of Civil Engineering and in the field of Mechanical Engineering, skills that allow the integrated approach of aspects related to the implementation of renewable energy source conversion system mixes in the energy efficient built environment. The main directions for the development of the university career in teaching and scientific research are presented.

In the third part of the habilitation thesis (B-iii) a selective bibliography is presented which includes 54 scientific articles, 7 books, 2 book chapters and 10 patents published by the author directly related to the field of the habilitation thesis. Of these, 28 are published as first author, 45 as co-author, 13 in ISI rated journals with a cumulative impact factor of 48.676 (Energy and Buildings - Q1, Renewable Energy - Q1, Applied Thermal Engineering - Q1, Journal of Renewable and Sustainable Energy - Q3, ASCE Journal of Energy Engineering - Q3, Energies - Q3, Environmental Engineering and Management Journal - Q4), 28 are WOS indexed and 40 are SCOPUS indexed. The books and book chapters are published in prestigious international (Woodhead Publishing, Springer, COST) and national (AGIR, Transilvania University of Braşov) publishing houses.

Brasov

24.10.2024

Conf. dr. ing. Macedon-Dumitru MOLDOVAN

