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Editorial

Modelling and Simulation of Heat Pumps for Simultaneous Heating and Cooling, a Special Issue

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Refrigeration and heat pump systems are used as cooling and heating devices, but each one can also carry out both cooling and heating. Reversible heat pumps were first used for heating or cooling alternatively. However, the best COP is obtained when the heating and cooling productions are simultaneous. In French, the word "thermofrigopompe" refers to these refrigeration systems or heat pumps for simultaneous heating and cooling (HPS).

Situations in which simultaneous demands coexist are numerous:

- Space heating and cooling of highly glazed buildings.
- Server room cooling and space heating in office buildings.
- Space cooling and domestic hot water production in hotels.
- Space cooling and desalination in coastal regions.
- Ice rink cooling and swimming pool heating in the same complex.
- Heat recovery in refrigeration systems in the agro-food industry.

Some of the specific characteristics of heat pumps for simultaneous heating and cooling are the presence of extra heat exchangers used to balance thermal production and demand with an external source or sink, such as ambient air or geothermal energy, an associated operating strategy, and storage systems that help enlarge the simultaneity of hot and cold productions. This Special Issue reviews past studies, collects new studies on the subject, and presents best practices for the design, performance assessment, and optimisation of heat pumps for simultaneous heating and cooling.

An introductory article presents the uses of heat pump productions in the form of an analysis of the thermal demands of different types of buildings and a literature review of real installations and experimental systems, which are the bases of the construction of numerical models [1]. The applications of HPSs are diverse: space heating and cooling, domestic hot water (DHW), hot water for desalination processes, etc. Means and methods for improving the performance of refrigeration cycles and the management of heat and cold productions are developed, including modelling and simulation. As heat fluxes do not have the same quality at high and low temperatures, an exergy analysis is likely to be employed to assess the performance. The minimisation of exergy destruction or entropy generation is a fully adapted method to optimise these systems. New refrigeration circuit architectures were designed. Focus was paid to refrigerants. Prototypes combining heating–cooling, heating–cooling–DHW, and cooling–desalination have been developed, built, and tested to validate the models. Even though a strong simultaneity of thermal demands is essential, the results show that HPSs are generally very efficient systems.

Artuso et al. propose an article on the dynamic modelling and validation of an air-to-water reversible R744 heat pump for high-energy-demand buildings [2]. It presents a complete model for the compressor's behaviour and for discretised heat exchangers. The validation is performed in both steady-state and transient regimes.

Pardiñas et al. publish an article on a CO_2 integrated system for heating, cooling, air conditioning, and refrigeration for a supermarket [3]. They develop a dynamic system model in Modelica and compare their simulations to the experimental results.

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They work on the system's architecture by implementing a vapour injection to achieve significant improvements.

Shin et al. present a means of saving energy for an HPS by modifying the indoor set temperature within an acceptable comfort range [4]. This method enables the operating time to be enlarged in a simultaneous mode. They use original concept diagrams to present their ideas.

Byrne and Lalanne present a more industrial application [5]. A parametric study is performed on an innovative system for heating and cooling or long-duration energy storage using pumped-hydro and carbon dioxide transcritical cycles. This article shows new possibilities for simultaneously heating and cooling or for storing and then simultaneously heating and cooling for other purposes.

The performance of simultaneous heating and cooling systems is high when the thermal demand is also simultaneous. A minimum daily ratio of simultaneous needs (RSN) was estimated in a range from 15 to 30%. The performance has to be assessed both in terms of COP (first principle of thermodynamics) and exergy efficiency (second principle of thermodynamics) to take into account the difference in energy types or qualities between hot and cold productions. Future developments will be led on coupling the heat and cold demands for groups of buildings, districts, or industries, and on the reduction in exergy destruction in innovative systems and components.

To the date of the submission of this editorial (25 July 2022), the five articles of this Special Issue already counted 2922 abstract views and 3586 full-text views, and were cited six times. I, as its Guest Editor, hope that this Special Issue on the modelling and simulation of heat pumps for simultaneous heating and cooling will continue to be read and cited, and that it will find the highest usefulness possible in the scientific community.

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