Organiza: UNIVERSIDAD DE MURCIA · CAMPUS MARE NOSTRUM

V ENCUENTRO
Ingeniería de la Energía

Patrocinadores:

Soltec · anpier · TAKASAGO Cátedra Takasago Industria y Mantenimiento 4.0 · cas CÁTEDRA DEL AGUA Y LA SOSTENIBILIDAD · REPSOL · ISF Murcia · cemuge · Cieza · EUROVÉRTICE · AEDIVE · Publicaciones DM · LASOLAR · aemener · Concawe · Atecyr · Colegio Oficial de Ingenieros Industriales de la Región de Murcia (COIIRM)

ACTAS DEL CONGRESO

V ENCUENTRO DE INGENIERÍA DE LA ENERGÍA DEL CAMPUS MARE NOSTRUM

Editores:

Mariano Alarcón García (Editor)

Manuel Seco Nicolás (Co-editor)

ISBN: 978-84-09-29971-3

Dirección web de congreso: V-EIECMN

Quinta edición del Encuentro orientado a servir de espacio de reunión para tratar las distintas facetas de las aplicaciones de la Energía en los ámbitos académico y profesional, así como de instituciones y empresas en el que compartir trabajos, se muestren avances creando un espacio virtual de debate y reflexión en el que plantear soluciones a los importantes retos que la Sociedad tiene en el ámbito de la Energía, englobado en el ODS-7, *Energía asequible y no contaminante*, desde una vocación tecnológica pero a la vez con sensibilidad social.

Universidad de Murcia

Campus Mare Nostrum

Del 23 al 26 de noviembre de 2020

COMPARISON BETWEEN HEAT PUMP AND SOLAR ENERGY FOR DOMESTIC HOT WATER PRODUCTION

Ikbal Ait Yala(12); Driss Nehari(1); José Ramón García-Cascales(2); Fernando Illán Gómez(2)
ikbal.aityala@edu.upct.es
(1) Smart Structure Laboratory, University Center of Ain-Temouchent, 46000 Ain Temouchent, Algeria[2]-
(2)Thermal and Energy Systems Modeling, Universidad Politécnica de Cartagena, Dr Fleming, s/n, 30202 Cartagena, Murcia, Spain

ABSTRACT:
In this survey, a comparison between the heat pump and the solar system assisted by a natural gas auxiliary heater in terms of energy consumption and CO2 emissions has been conducted.
Primarily, the heat pump has been programmed in Fortran to create several Trnsys components which has allowed its validation against some experimental values obtained in our lab. After, it has been used to model the whole system for the production of domestic hot water for a single-family home.
The results show that the energy consumption and the CO_2 emissions are less important in case of the heat pump.
Overall it may say that for the given operating conditions, the heat pump system is the best choice for the production of the domestic hot water DHW.

Keywords: Heat Pump, Solar system, Trnsys, DHW

1. Introduction:

The natural working fluids are the key to reduce our global impact. CO_2 is one of the natural fluids which can decrease the environmental burden on the planet atmosphere.
Its GWP (Global Warming Potential) is 1300 times smaller than a standard heat pump refrigerant such as the r134a [1].
In the last decades, the use of CO_2 heat pumps for the production of domestic hot water has become a subject of many research studies [2]. In order to take advantage of the high efficient proprieties of the refrigerant and reach high COP values the system must be good designed and well operated [3]. It was proven that a good characterization of the heating performances result in a good designed heat pump system [4].
The model has been analyzed using the Trnsys simulation for a whole year, then compared with a set of solar collectors assisted by a natural gas heater in terms of the primary energy consumption and the CO_2 emissions.

2. Domestic Hot Water Generation Systems

2.1. DHW system based on a heat pump assisted by an auxiliary heater:

Geothermal heat pumps (Fig 2.1) use the Earth as a heat sink in the summer and a heat source in the winter, and therefore rely on the relative warmth of the earth for their heating and cooling production.
Through a system of underground (or underwater) pipes, heat from the ground is absorbed into the fluid and then passes through a heat exchanger into the heat pump. As the ground stays at a fairly constant temperature under the surface, the heat pump can be used throughout the year.

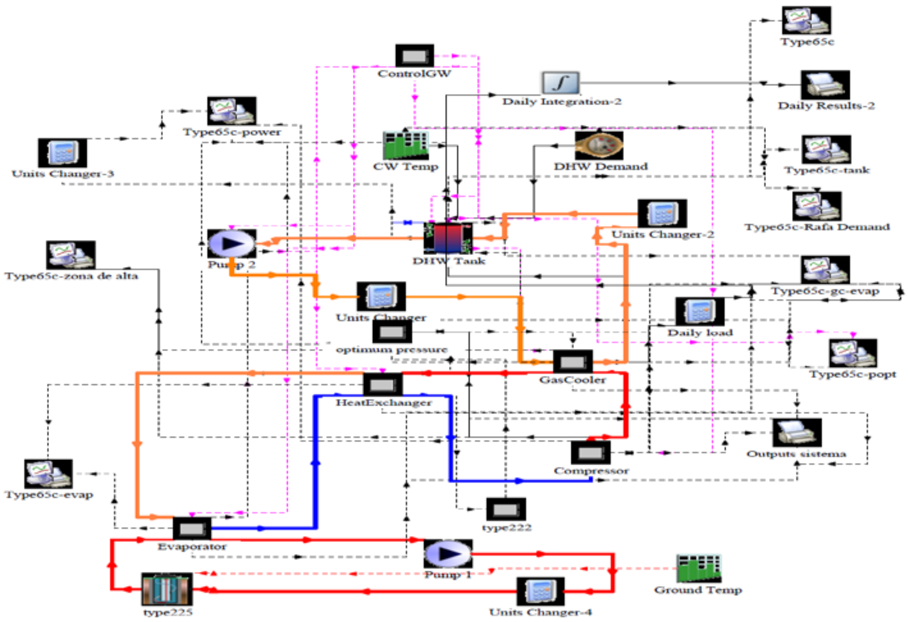

Figure 2.1: DHW system based on a heat pump assisted by an auxiliary heater

2.2. DHW system based on a solar system assisted by an auxiliary heater:

Solar Domestic Hot Water systems (Fig 2.2) are specifically designed to deliver 100% of the hot water requirements in summer and 40-80% of the total annual hot water demand. They include a supplementary heater (e.g. an integrated electric or gas heater). Or they are operated as pre-heaters.
These systems are particularly popular in regions with no or low space heating demand. In Spain and other countries, solar hot water systems are now mandatory in new buildings.

Solar domestic hot water systems use a pump to circulate water from the thermal storage tank through the collectors. Solar heated water is stored in a tank, and an auxiliary heater can be used if desired. In many cases the auxiliary heater is the preexisting conventional water heater.

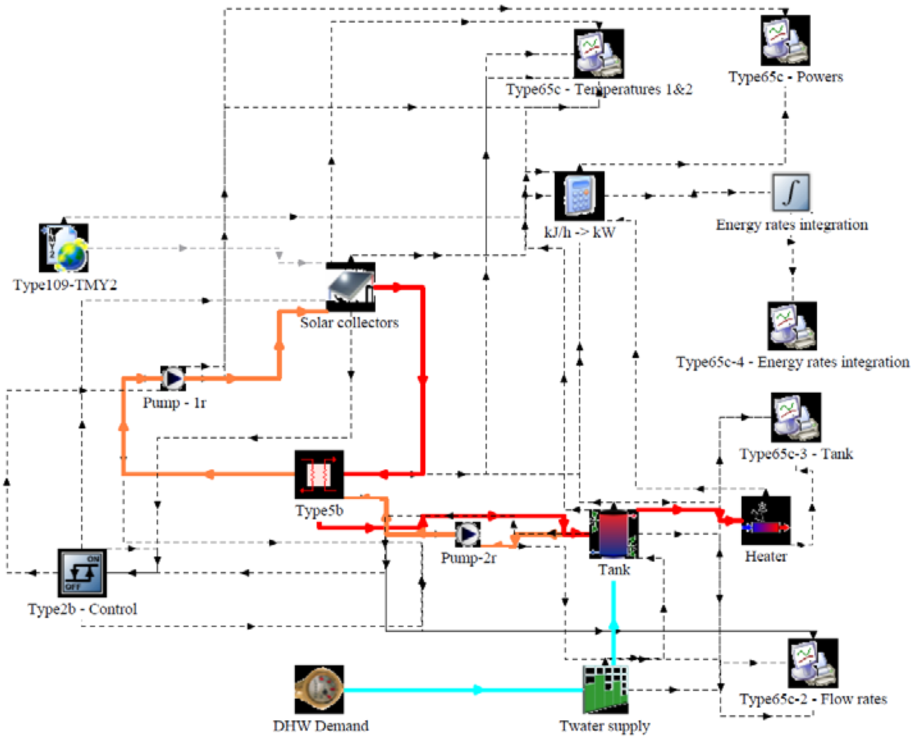

Figure 2.2: DHW system based on a solar system assisted by an auxiliary heater

The indexes used to calculate the primary energy consumed and the CO2 emissions produced by each system are those published by the Spanish Ministry of Industry, Energy and Tourism in 2016 according to the yearly energy consumption of the country. The coefficients are in Table 1.

Table 1: Conversion factors of the calculation of primary energy consumption and CO_2 emissions.

	Conversion factors
Conventional electricity in the peninsula	2.368 kWh primary energy/kWh final energy
Natural gas	1.195 kWh primary energy/kWh final energy
CO_2 coefficient for electricity	0.28 kg CO_2/kWh
CO_2 coefficient for the natural gas	0.22530522 kg CO_2/kWh

3. Conclusion:

In this work, a model to characterise the behaviour of a heat pump have been presented. This has been
programmed in Fortran to create several Trnsys components which has allowed its validation against some experimental values obtained in our lab. After, it has been used to model a heat pump for the production of domestic hot water for a single-family home and compared to a conventional solar system. The solutions studied consider a support heater to satisfy the demand whenever the heat pump or the solar system are not capable. The results show that the heat pump system consumption in terms of primary energy and the CO2 emissions are both greater in the case of the solar system.

References:

[1] Stene, J. (n.d.). HIGH-EFFICIENCY CO 2 HEAT PUMP WATER HEATER SYSTEMS FOR RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS Evaluation of Different Heat Pump Water Heater Systems, 2–8.

[2] Staffell, I., Brett, D., Brandon, N., & Hawkes, A. (2012). A review of domestic heat pumps. Energy and Environmental Science, 5(11), 9291–9306. https://doi.org/10.1039/c2ee22653g Aprea, C., Greco, A., & Maiorino, A. (2013).

[3] The substitution of R134a with R744: An exergetic analysis based on experimental data. International Journal of Refrigeration, 36(8), 2148–2159. https://doi.org/10.1016/j.ijrefrig.2013.06.012.

[4] Nekså, P., Rekstad, H., Zakeri, G. R., & Schiefloe, P. A. (1998). CO2-heat pump water heater: Characteristics, system design and experimental results. International Journal of Refrigeration, 21(3), 172–179. https://doi.org/10.1016/S0140-7007(98)00017-6.

Comités del V Congreso Encuentro de Ingeniería de la Energía del Campus Mare Nostrum

Comité organizador

Mariano Alarcón García (Presidente)
Manuel Seco Nicolás
Francisco del Cerro Velázquez
Juan Pedro Luna Abad
Alfonso P. Ramallo González
Fernando Lozano Rivas

Comité científico

Alfonso P. Ramallo González (UM)
Antonia Baeza Caracena (UM)
Antonio González Carpena (UM)
Antonio Urbina Yeregui (UPCT)
Antonio Viedma Robles (UPCT)
Félix Cesáreo Gómez de León Hijes (UM)
Fernando Illán Gómez (UPCT)
Francisco del Cerro Velázquez (UM)
Francisco Vera García (UPCT)
Gloria Alarcón García (UM)
Gloria Villora Cano (UM)
Joaquín Zueco Jordán (UPCT)
José A. Almendros Ibáñez (UCLM)
José Miguel Martínez Paz (UM)
José Ramón García Cascales (UPCT)
Juan Pedro Luna Abad (UPCT)
Juan Pedro Montávez Gómez (UM)
Manuel Lucas Miralles (UMH)
Manuel Seco Nicolás (UM)
Mariano Alarcón García (UM)
Miguel Ángel Zamora Izquierdo (UM)
Pedro J. Vicente Quiles (UMH)
Teresa Maria Navarro Caballero (UM)
Teresa Vicente Vicente (UM)

ACTAS DEL CONGRESO V ENCUENTRO DE INGENIERÍA DE LA ENERGÍA DEL CAMPUS MARE NOSTRUM

PROCEEDINGS OF THE V MEETING OF ENERGY ENGINEERING OF CAMPUS MARE NOSTRUM

Editor

Mariano Alarcón García

Co-editor

Manuel Seco Nicolás

Murcia 2021