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Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

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Citation for published version (APA):

Johra, H. (2022). *Overview of the Coefficient of Performance (COP) for conventional vapour-compression heat pumps in buildings*. Department of the Built Environment, Aalborg University. DCE Lecture notes No. 79

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DEPARTMENT OF THE BUILT ENVIRONMENT
AALBORG UNIVERSITY

Overview of the Coefficient of Performance (COP) for conventional vapour-compression heat pumps in buildings

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Department of the Built Environment
Division of Sustainability, Energy & Indoor Environment

Lecture Notes No. 79

**Overview of the Coefficient of Performance (COP)
for conventional vapour-compression
heat pumps in buildings**

by

Hicham Johra

January 2022

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Published 2022 by
Aalborg University
Department of the Built Environment
Thomas Manns Vej 23
DK-9220 Aalborg Ø, Denmark

Printed in Aalborg at Aalborg University

ISSN 1901-7286
Lecture Notes No. 79

1. Foreword

The aim of this lecture note is to give an overview of the Coefficient of Performance (COP) of conventional vapour-compression heat pumps for building applications (space cooling, space heating and domestic hot water production). The COP data has been collected from various experimental and numerical studies reported in peer-reviewed scientific journals and conference papers, technical information from manufacturers and academic documents (Ph.D. and Master theses). The COP of different heat pumps is presented as a function of the temperature span (temperature lift) between the heat source and the heat sink.

2. Introduction

Heat pumps are an excellent solution to supply heating and cooling for indoor space conditioning and domestic hot water production. Conventional heat pumps are typically electrically driven and operate with a vapour-compression thermodynamic cycle of refrigerant fluid to transfer heat from a cold source to a warmer sink. This mature technology is cost-effective and achieves appreciable coefficients of performance (COP). The heat pump market demand is driven up by the urge to improve the energy efficiency of building heating systems coupled with the increase of global cooling needs for air-conditioning.

For heating and cooling systems, the Coefficient of Performance is the ratio of useful heating or cooling power (or energy) provided to work power (energy) input to the system. The COP is adimensional (no unit). The equation of the Coefficient of Performance (COP) for heating and cooling systems is as follows:

$$COP = \frac{|Q|}{W}$$

Where Q is the useful heating or cooling power (or energy) provided (heat removed from the cold heat source/reservoir for cooling systems; heat injected into the warm heat sink/reservoir for heating systems), and W is the net work power (or energy) input to the heating/cooling system. Higher COPs correspond to higher energy efficiency and thus lower energy usage and operating costs.

3. Overview of COP for conventional vapour-compression heat pumps in buildings

One can see in *Figure 1* that vapour-compression heat pumps typically have a Carnot efficiency between 40% and 60% for temperature spans compatible with building applications: indoor space conditioning and domestic hot water production (temperature span of 20-60 K). Vapour-compression heat pumps thus typically have a COP ranging between 2 and 5 for common building applications.

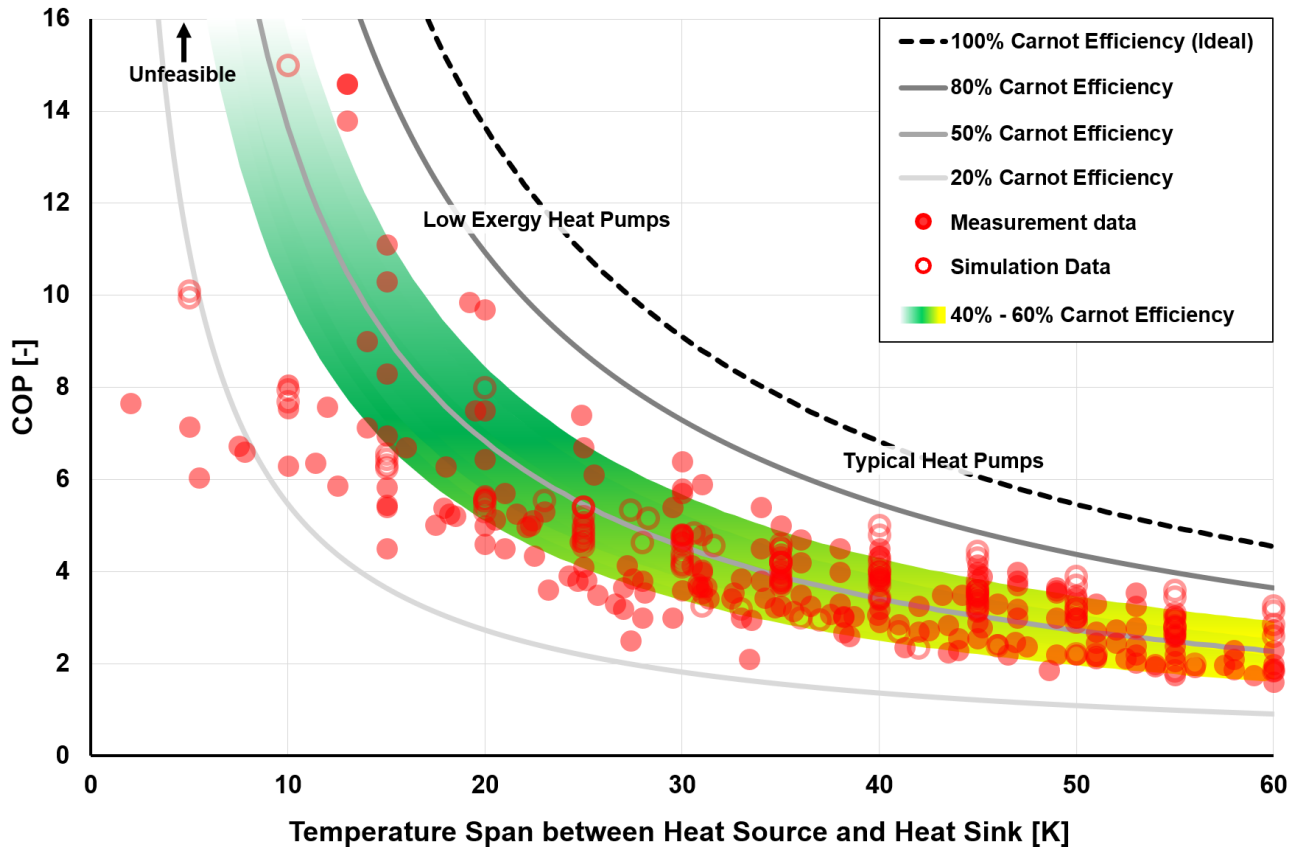


Figure 1: Performance overview of conventional vapour-compression heat pumps for building applications: Coefficient of Performance (COP) as a function of the temperature span (temperature lift) between the heat source and the heat sink. Data collected from [1][2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22].

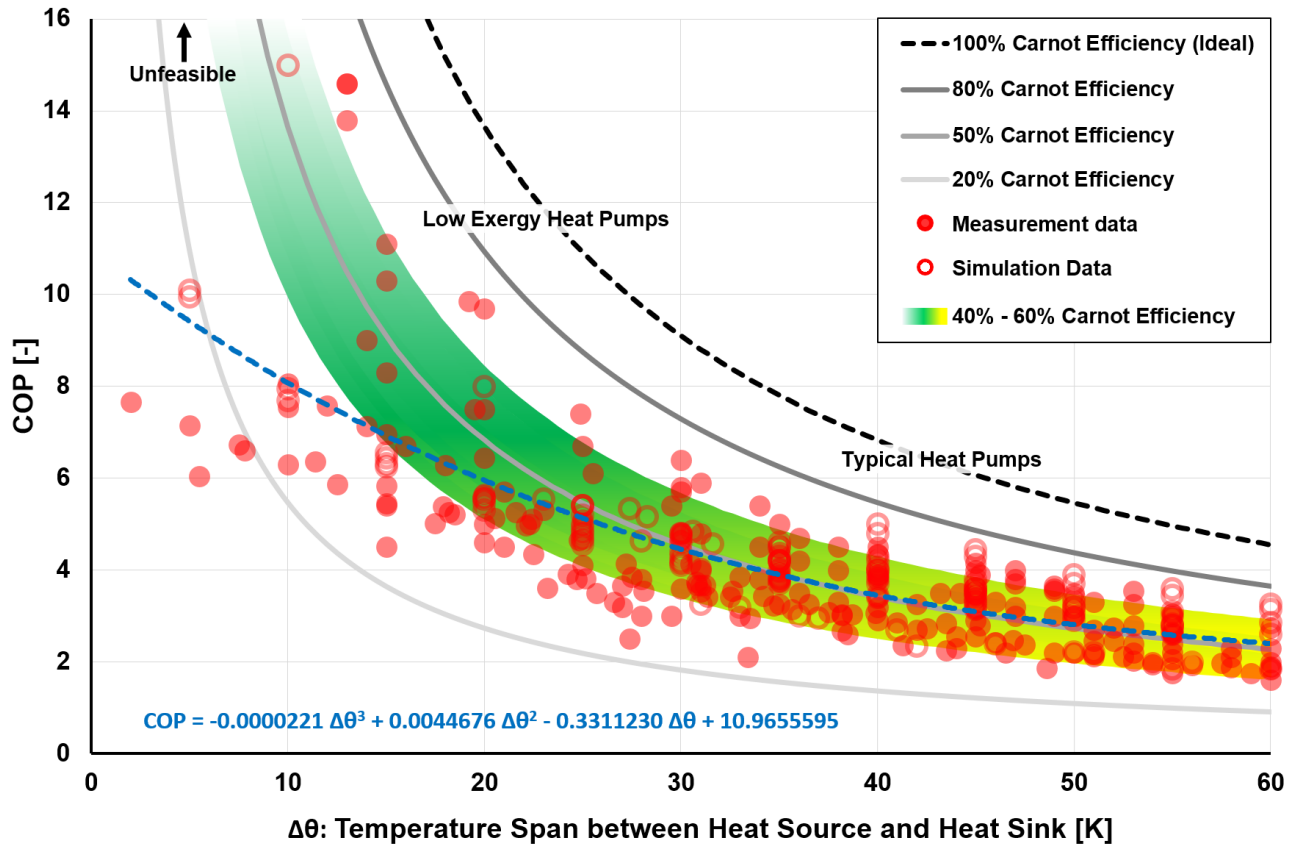


Figure 2: Performance overview of conventional vapour-compression heat pumps for building applications: Coefficient of Performance (COP) as a function of $\Delta\theta$: the temperature span (temperature lift) between the heat source and the heat sink; polynomial fitting curve. Data collected from [1][2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18][19][20][21][22].

References

- [1] Aguilar FJ, Aledo S, Quiles PV. Experimental study of the solar photovoltaic contribution for the domestic hot water production with heat pumps in dwellings. *Appl Therm Eng* 2016;101:379–89. <https://doi.org/10.1016/j.applthermaleng.2016.01.127>.
- [2] Meggers F, Ritter V, Goffin P, Baetschmann M, Leibundgut H. Low exergy building systems implementation. *Energy* 2012;41:48–55. <https://doi.org/10.1016/j.energy.2011.07.031>.
- [3] Mohanraj M, Belyayev Y, Jayaraj S, Kaltayev A. Research and developments on solar assisted compression heat pump systems – a comprehensive review (Part-B:applications). *Renew Sustain Energy Rev* 2018;83:124–55. <https://doi.org/10.1016/j.rser.2017.08.086>.
- [4] Y.H. Kuang, R.Z. Wang (2006). Performance of a multi-functional direct-expansion solar assisted heat pump system. *Solar Energy* 80(7), 795-803. <https://doi.org/10.1016/j.solener.2005.06.003>.
- [5] S. Ito, N. Miura, K. Wang (1999). Performance of a heat pump using direct expansion solar collectors. *Solar Energy* 65(3), 189-196.
- [6] E. Torres-Reyes, J. Cervantes de Gortari (2001). Optimal performance of an irreversible solar-assisted heat pump. *Exergy Int. J.* 1(2), 107-111.
- [7] F.B. Gorozabel Chata, S.K. Chaturvedi, A. Almogbel (2005). Analysis of a direct expansion solar assisted heat pump using different refrigerants. *Energy Conversion and Management* 46, 2614-2624.
- [8] M. Izquierdo, P. de Agustín-Camacho (2015). Solar heating by radiant floor: Experimental results and emission reduction obtained with a micro photovoltaic-heat pump system. *Applied Energy* 147, 297-307. <http://dx.doi.org/10.1016/j.apenergy.2015.03.007>.
- [9] A. Moreno-Rodríguez, A. González-Gil, M. Izquierdo, N. Garcia-Hernando (2012). Theoretical model and experimental validation of a direct-expansion solar assisted heat pump for domestic hot water applications. *Energy* 45, 704-715. <http://dx.doi.org/10.1016/j.energy.2012.07.021>.
- [10] Y.W. Li, R.Z. Wang, J.Y. Wu, Y.X. Xu (2007). Experimental performance analysis and optimization of a direct expansion solar-assisted heat pump water heater. *Energy* 32, 1361-1374. <https://doi.org/10.1016/j.energy.2006.11.003>.
- [11] L. Gasser, S. Flück, M. Kleingries, C. Meier, M. Bäschmann, B. Wellig (2017). High efficiency heat pumps for low temperature lift applications. *Proceedings of the 12th IEA Heat Pump Conference 2017*.
- [12] J. Zhang, R.Z. Wang, J.Y. Wu (2007). System optimization and experimental research on air source heat pump water heater. *Applied Thermal Engineering* 27, 1029-1035. <https://doi.org/10.1016/j.applthermaleng.2006.07.031>.
- [13] V. Trillat-Berdal, B. Souyri, G. Fraisse (2006). Experimental study of a ground-coupled heat pump combined with thermal solar collectors. *Energy and Buildings* 38, 1477-1484. <http://dx.doi.org/10.1016/j.enbuild.2006.04.005>.
- [14] I. Sarbu, C. Sebarchievici (2014). General review of ground-source heat pump systems for heating and cooling of buildings. *Energy and Buildings* 70, 441-454. <http://dx.doi.org/10.1016/j.enbuild.2013.11.068>.
- [15] B. Sanner, C. Karytsas, D. Mendrinou, L. Rybach (2003). Current status of ground source heat pumps and underground thermal energy storage in Europe. *Geothermics* 32, 579-588. [http://dx.doi.org/10.1016/S0375-6505\(03\)00060-9](http://dx.doi.org/10.1016/S0375-6505(03)00060-9).
- [16] S. Sanaye, B. Niroomand (2010). Horizontal ground coupled heat pump: Thermal-economic modeling and optimization. *Energy Conversion and Management* 51, 2600-2612. <https://doi.org/10.1016/j.enconman.2010.05.026>.

- [17]<https://sparenergi.dk/>, 2013
- [18] DVI VV Combi & Single Manufacturer data
- [19]B. Gillan (2016). Investigating the potential of low exergy thermal sources to improve the COP of heat pumps. Master Thesis Report. University of Strathclyde.
- [20]Haller, Michel & Haberl, R. & Carbonell, Daniel & Philippen, Daniel & Frank, Elimar. (2014). SOL-HEAP. Solar and Heat Pump Combisystems.
- [21]J. Pospisil, M. Spilacek, P. Charvat (2019). Seasonal COP of an air-to-water heat pump when using predictive control preferring power production from renewable sources in the Czech Republic. Energies 12, 3236. <https://doi.org/10.3390/en12173236>.
- [22]O. Ruhnau, L. Hirth, A. Praktijnjo (2019). Time series of heat demand and heat pump efficiency for energy system modeling. Scientific Data 6:189. <https://doi.org/10.1038/s41597-019-0199-y>.

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Lecture Notes No. 79