Development and evaluation of a building integrated aquifer thermal storage model

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An aquifer thermal energy storage (ATES) in combination with a heat pump is an excellent way to reduce the net energy usage of buildings. The use of ATES has been demonstrated to have the potential to provide a reduction of between 20 and 40% in the cooling and heating energy use of buildings. ATES systems are however a complex system to analyse as a number of ground conditions influence heat losses within the aquifer. ATES is also not confined from the sides and is therefore vulnerable to heat losses through conduction, advection and dispersion. The analyses of ATES system is even further complicated when the dynamic of a building is considered. When connected to a building, the temperature in the aquifer is influenced by the amount of heat exchange with the varying building load. Given the energy saving potentials of ATES systems in building operation, detailed understanding of the influence of buildings on the ATES systems and vice versa would facilitate improved operation and efficiency of ATES and building coupled systems. Therefore, taking into account the variations in the building and below ground conditions, there is the need for the development of a model that can potentially handle the dynamics on both sides. Finite element and finite volume methods are frequently used in the development of ATES models and proven as adequate tools for modelling complex ground conditions, however, most developed ATES models are often analysed independent of the building. Therefore, in this study, an ATES model that also integrates building dynamics is developed using the finite element method (FEM). The developed model was validated using data from an ATES and building in the Netherlands. The developed model was shown to have an absolute mean error of 0.17°C and 0.12°C for the cold and warm wells respectively.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Eindhoven University of Technology
Contributors: Bozkaya, B., Li, R., Labeodan, T., Kramer, R., Zeiler, W.
Number of pages: 10
Pages: 620-629
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Applied Thermal Engineering
Volume: 126
ISSN (Print): 1359-4311
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.14 SJR 1.505 SNIP 1.837
Web of Science (2017): Impact factor 3.771
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.78 SJR 1.438 SNIP 1.851
Web of Science (2016): Impact factor 3.444
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.32 SJR 1.683 SNIP 1.884
Web of Science (2015): Impact factor 3.043
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.16 SJR 1.539 SNIP 2.187
Web of Science (2014): Impact factor 2.739
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.31 SJR 1.466 SNIP 2.469
Web of Science (2013): Impact factor 2.624
ISI indexed (2013): ISI indexed yes