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EXPLORING THE TECHNICAL AND ECONOMIC FEASIBILITY OF USING THE URBAN WATER SYSTEM AS A SUSTAINABLE ENERGY SOURCE

ABSTRACT

The objective of this paper is to determine the technical and economic feasibility of an alternative energy system in which the urban water system functions as a source for sustainable energy supply. It is demonstrated that aquifer thermal energy storage supplemented with surface water heat collection in summer, yields sufficient heat to compensate total heat demand of a residential district. Using the urban water system as energy source makes natural gas supply obsolete, provides a CO2 reduction of 60% and is preferable in terms of costs compared to conventional gas based central heating installations. The feasibility of the urban groundwater system, urban surface water system, and the economic feasibility are determined in this paper. The local groundwater feasibility to supply the design discharge is determined by soil and aquifer characteristics from the national groundwater database, reference projects, and bore-hole data. A heat balance model is used to quantify effects on the water system. Internal rate of return calculation for the investments and full lifetime exploitation costs are used to determine the economic feasibility of the concept. In summer, there is a net water temperature decrease of 1.5-1.6 °C. Water quality and ecological improvement take place because a lower temperature results in increasing oxygen content. Moreover, the expected water temperature increase by climate change can be prevented. The concept is economically feasible. Considering the full lifetime and all investment and exploitation costs, the concept is more profitable than a conventional system.

KEYWORDS

sustainable energy, urban water, aquifer thermal energy storage

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REFERENCES [view full list]

1. Yamamoto, H., Yamaji, K., Sustainable Energy Path, Thermal Science, 9 (2005), 3, pp. 7-14
2. ***, International Energy Agency, Energy Conservation through Energy Storage Programme, 2005, Paris
3. Stojiljkovič, D. T., et al., Pilot Plant for Exploitation of Geothermal Waters, Thermal Science, 10 (2006), 4, pp. 195-203
4. Buitenhuis, H., System Concepts with Aquifer Thermal Energy Storage; Experiences in the Netherlands, Proceedings (Eds. K. Ochifuji, K. Nagano), Megastock, Hokkaido University, Sapporo, Japan, 1997, pp. 425-430
5. Valan Arasu, A., Sornakumar, S. T., Performance Characteristics of Solar Parabolic trough Collector Hot Water Generation System, Thermal Science, 10 (2006), 2, pp. 167-174
6. Nordell, B., Hellström, G., High Temperature Solar Heated Seasonal Storage System for Low Temperature Heating of Buildings, Solar Energy, 69 (2000), 6, pp. 511-523
7. Snijders, A. L., Aquifer Thermal Energy Storage in the Netherlands, Status Beginning of 2005, http://www.iftechinternational.com/pdf/Status%20ATES%20NL%202005.pdf
8. Zanstra, A., Building from House to City; Some Aspects of Urbanism, Housing, Architecture, Floor Plans and Technical Facilities of Houses (in Dutch), Van Oorschot, Amsterdam, 1946
9. Holdsworth, B., Cool Thinking, Unlocking Earth's Energy, Refocus, 5 (2004), 2, pp. 28-30
10. ***, SenterNovem, Reference Houses Greenfield Developments (in Dutch), Sittard, the Netherlands, 2006
11. ***, Netherlands Society for Underground Heat Storage, Guidelines Underground Heat Storage (in Dutch),Woerden, the Netherlands, 2006
12. Speelman, H., Houtman, H., Groundwater Map of the Netherland (in Dutch), Dienst Grondwaterverkenning TNO, Delft, the Netherlands, 1979
13. ***, TNO, http://regisloket.nitg.tno.nl/rgs_map/index.html
14. ***, TNO, http://dinolks01.nitg.tno.nl/dinoLks/DINOLoket.jsp
15. Buik, N. A., Willemsen, G., Clogging Rates in Recharge Wells in Porous Media, Proceedings (Ed. P. J. Dillen), 4th International Symposium on Artificial Recharge, Adelaide, Australia, 2002, pp. 195-198
16. Sweers, H. E., A Nomogram to Estimate the Heat-Exchange Coefficient at the Air-Water Interface as a Function of Wind Speed and Temperature; a Critical Survey of Some Literature, Journal of Hydrology, 30 (1976), 4, pp. 375-401
17. ***, Royal Dutch Meteorological Institute, http://www.knmi.nl/klimatologie
18. Edinger, J. E., Geyer, J. C., Heat Exchange in the Environment., John Hopkins University, Baltimore, Md., USA, 1965
19. Brunt, D., Notes on Radiation in the Atmosphere, Quarterly Journal of The Royal Meteorological Society, 58 (1932), pp. 389-418
20. Boderie, P., Dardengo, L., Heat Pollution in Surface Water and Exchange with the Atmosphere, A Review of Methods and Models, Delft Hydraulics Report Q3315, 2003, Delft, The Netherlands
21. Iziomon, M. G., Mayer, H., Matzarakis, A., Downward Atmospheric Longwave Irradiance under Clear and Cloudy Skies: Measurement and Parameterization, Journal of Atmospheric and Solar-Terrestrial Physics, 65 (2003), 10, pp. 1107-1116
22. Wiggers, J. B. M., et al., Processes in the Water Environment (in Dutch), Delft University of Technology, Delft, The Netherlands, 1998
23. Boyd, M., Kasper, B., Analytical Methods for Dynamic Open Channel Heat and Mass Transfer Methodology for the Heat Source Model, Version 7.0, http://www.heatsource.info
24. ***, Measurement and Estimation of Evaporation and Evapotranspiration, World Meteorological Organization, Technical Note 83, Geneva, Switzerland, 1966
25. Van Mazijk, A., Bolier, G., Water Quality Management (in Dutch), Lecture Notes, Delft University of Technology, Delft, The Netherlands, 2002

26. Bowen, I. S., The Ratio of Heat Loss by Convection and Evaporation from Any Water Surface, Physical Review, 27 (1926), 2, pp. 779-787
27. Radtke, D. B., Gibs, J., Iwatsubo, R. T., National Field Manual for the Collection of Water-Quality Data: Field Measurements, USGS TWRI Book 9, Reston, Va., USA, 1998
28. Pakhurst, J. D., Pomeroy, D., Oxygen Absorption in Stream, Journal of the Sanitary Engineering Division, American Society of Civil Engineers, 98 (1972), 1, pp. 102-124
29. Weil, R. L., Maher, M. W., Handbook of Cost Management, John Wiley and Sons, Inc., New York, USA, 2005
30. Loeve, R., Claassen, T., Droogers, P., Climate Change and Water Quality (in Dutch), H2O, 39 (2006), 22, pp. 35-38
31. ***, IF Technology, Design Standards for Aquifer Thermal Energy Storage (in Dutch), Report nr. 1.9805/GW, Arnhem, The Netherlands, 2001
32. ***, European Council and Parliament, Directive 2000/60/EC Establishing a Framework for the Community Action in the Field of Water Policy, OJ L 327, Brussels, 2000
33. ***, Statistics Netherlands, Dutch Gas and Electricity Prices among the Highest in Europe, Web Magazine, May 3, 2007, http://www.cbs.nl

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