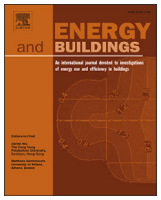
Energy & Buildings 323 (2024) 114752

Contents lists available at ScienceDirect

Energy & Buildings

journal homepage: www.elsevier.com/locate/enbuild



Optimized spatial tool for the implementation of ground source heat pump coupled with photovoltaic panels heating systems in urban areas

Adela Ramos-Escudero [a], Teresa Magraner [b], Isabel C. Gil-García [c,*]

[a] Water Management Department, Faculty of Civil Engineering and Geosciences, TU Delft, Stevinweg 1, 2600 GA, Delft, the Netherlands
[b] Dept. of Applied Thermodynamics, Universitat Politècnica València, Camino de Vera s/n, 46022, Valencia, Com. Valenciana, Spain
[c] Faculty of Engineering, Distance University of Madrid (UDIMA), C/ Coruña, km 38500, 28400, Collado Villalba, Madrid, Spain

ARTICLE INFO

Keywords:
Renewable heating systems
GIS
Ground source heat pump
Photovoltaic panels
MCDM

ABSTRACT

The growth of the urban population intensifies climate change due to the increase in activities that emit greenhouse gases, such as heating. However, proper urban planning and effective environmental policies can mitigate these impacts and foster a sustainable future. This study proposes an optimized spatial tool to implement renewable coupled heating systems in urban areas, combining geothermal heat pump technology with electricity generation through photovoltaic panels. The tool performs an exhaustive geospatial analysis that considers technical, economic, and socio-environmental criteria, offering multiple alternatives prioritized through multi-criteria evaluation methods. This facilitates the design of various scenarios according to the investment in renewable coupled systems for heating in buildings, in line with Sustainable Development Goals (SDG) 7, 11, and 13. The tool is evaluated in the city of Madrid, specifically in the neighborhood of Ciudad Lineal, generating a total of 2733 alternatives. Four scenarios are designed based on the annual subsidies provided by the Spanish Institute for Energy Diversification and Saving (IDAE) for heating and cooling using renewable energy sources. The first scenario, which includes 599 alternatives, manages to avoid emissions of 5 $MtCO_2$/year and primary energy savings of 278.9 GWh/year.

Nomenclature

Abbreviations

BHE	Borehole Heat Exchanger
Bi	Biomas
COP	Coefficient of heat pump performance
DHW	Domestic hot water
EED	Earth Energy Designer
GHG	Greenhouse Gas Protocol
GIS	Geographic Information Systems
GN	Natural gas
GSHP	Ground source heat pump
HVAC	Heating Ventilation Air Conditioning
IDAE	Spanish Institute for Energy Diversification and Saving
LCA	Lifecycle analysis
Mat	Construction materials
MCDM	Multi-Criteria Decision Making
NPV	Net present value
PV	Solar photovoltaic
PVT	Solar thermal
SCOP	Seasonal coefficient of performance in the heating season
SDG	Sustainable Development Goal
Thc	Thermoelectric cooler
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
TRNSYS	Transient System Simulation Tool
URBAN3R	GIS based tool to support urban regeneration
Wi	Wind

Variables

E_{demand}	Building heating demand (kWh/year)
q	heat extraction (W/m)
t_{op}	Annual facility operation time (h)
l_{BHE}	Total length of vertical heat exchanger (m)
E_{GEN}	Energy generated annually (kWh)

* Corresponding author.
E-mail address: isabelcristina.gil@udima.es (I.C. Gil-García).

https://doi.org/10.1016/j.enbuild.2024.114752
Received 19 June 2024; Received in revised form 19 August 2024; Accepted 30 August 2024
Available online 4 September 2024