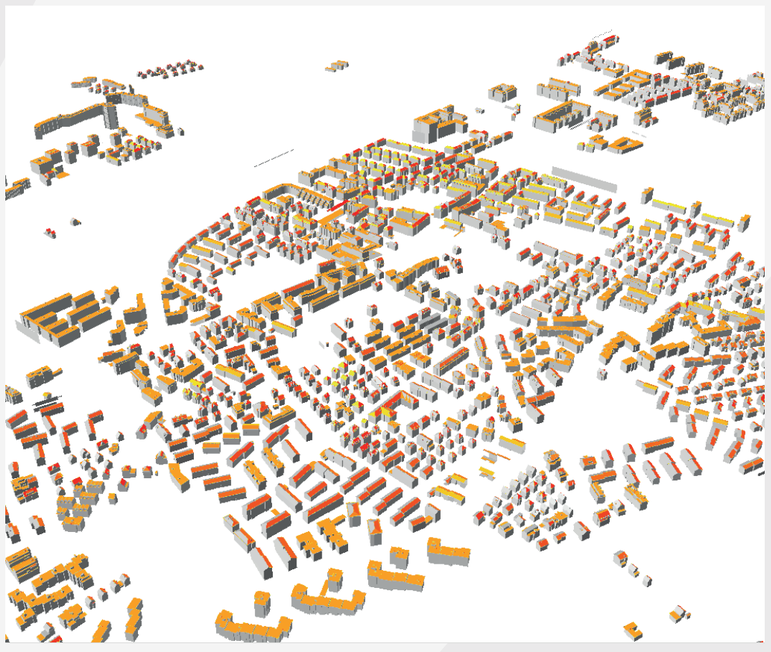
BUILDING AND URBAN ENERGY

GEO-SPATIAL ASPECTS OF URBAN ENERGY SYSTEMS

MOTIVATION AND AIM

Future cities, urban areas and buildings are expected to undergo a transformation towards more sustainable energy systems. This research aims at investigating the technological tradeoff between renewable energy based standalone systems and a small scale district heating system taking the total costs, carbon emissions savings and spatially and temporally differentiated energy demand and supply patterns into account.



Global solar radiation for 21st June 12pm, Altstetten, Zurich, Switzerland

METHODS

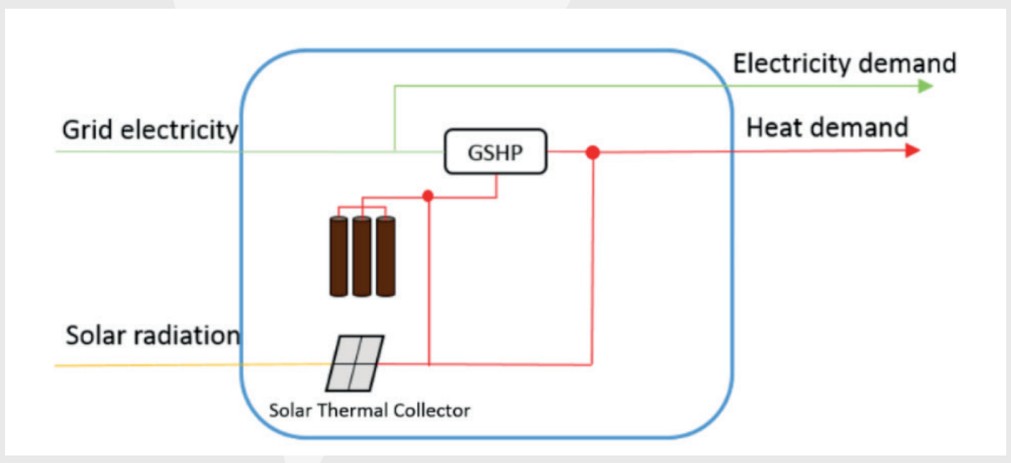
Energy hub modelling

a. Single buildings

The energy hub approach is used to select and size the optimal heat supply system for each of the buildings. Heating/cooling demand and renewable energy potential are the key inputs to this process. A multi objective optimization algorithm is used which minimizes the total costs and carbon emissions of the system.

b. District heating

The design and operation of a centralized district heating system for a cluster of buildings sourced by renewable energy is performed using the energy hub approach. GIS based methodology is developed for site selection for production units, optimal network layout and sizing of the district heating system. Constraints related to available supply, temperature levels, pump capacities and line losses will be integrated into the energy hub approach



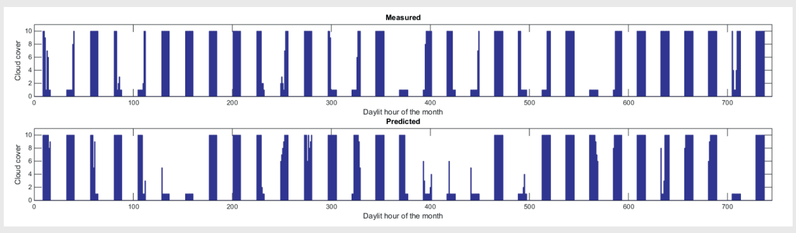
Example energy hub representing the energy system of a building consisting of a solar thermal system and a GSHP

Renewable energy potential

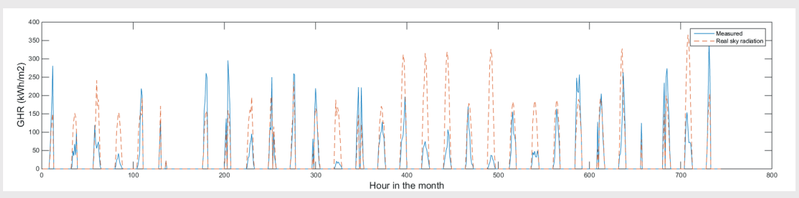
The two types of renewable energy based standalone systems that are studied are solar thermal systems and ground source heat pumps.

a. Solar energy potential

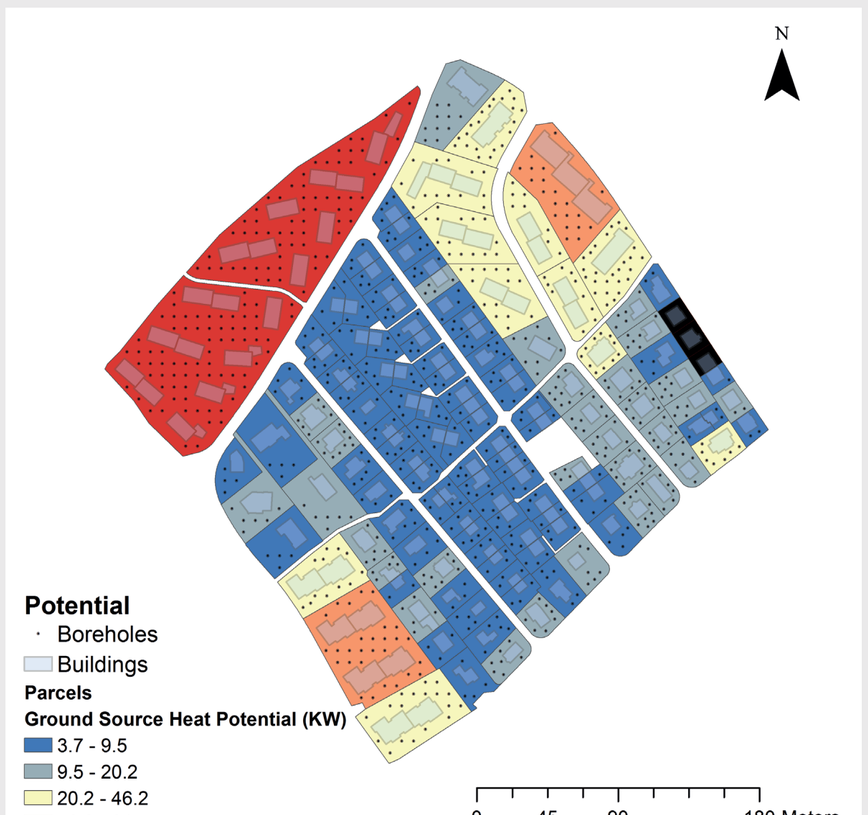
A GIS based method for solar radiation calculation combined with a cloud cover prediction model is developed to calculate the incoming solar radiation on a building rooftop on an hourly basis. A 3D building model, combined with data representing the local topography, is used as an input into the model. The methodology is validated with past weather data.



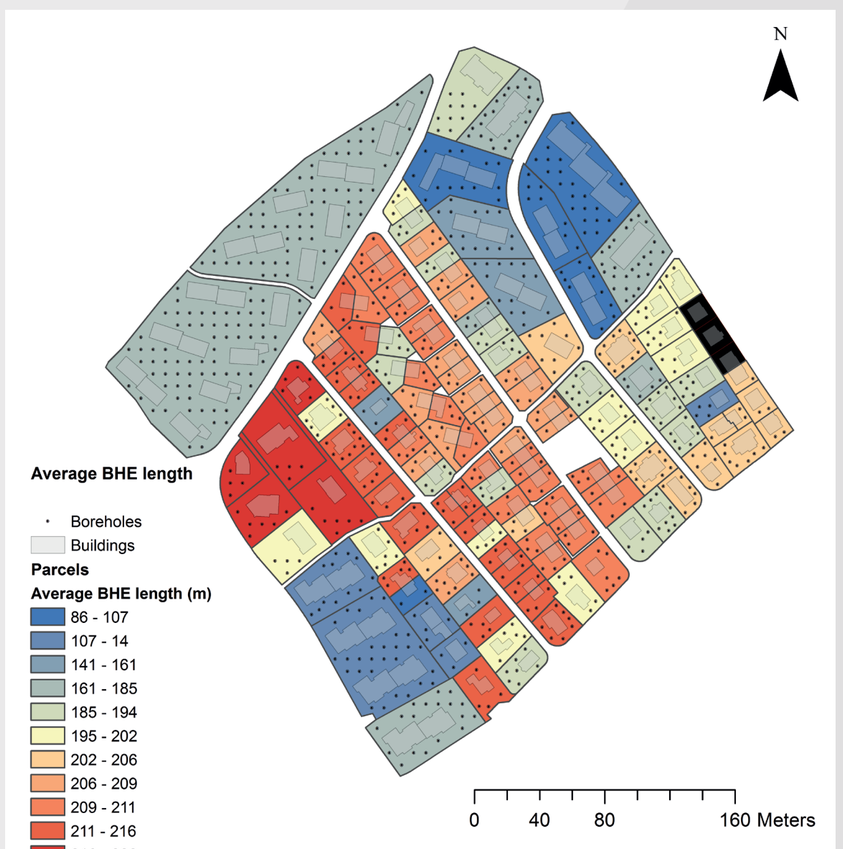
Measured vs predicted cloud cover (discrete states 1-10) for the month of January 2014



Comparison of the measured GHR with real sky radiation (cloud cover predicted)



Ground source heat potential per building parcel (kW), Altstetten, Zurich, Switzerland

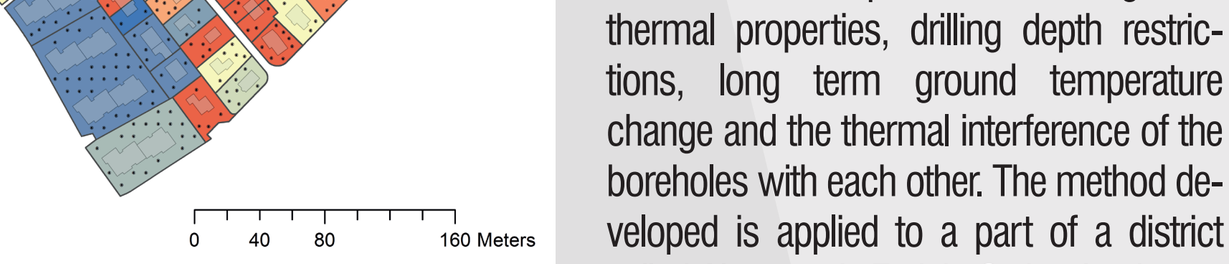


Average BHE length (design) per parcel, Altstetten, Zurich, Switzerland

b. Ground source heat potential

A GIS based method is developed to design and evaluate the operational performance of borehole heat exchangers (BHE) and calculate the ground source heat potential at the building level. This methodology takes into account the spatial variation of ground thermal properties, drilling depth restrictions, long term ground temperature change and the thermal interference of the boreholes with each other. The method developed is applied to a part of a district called Altstetten in Zurich, Switzerland.

BHE operation: Hourly variation of the heat demand met/unmet for a single BHE



BHE operation: Hourly variation of the mean fluid temperature in the BHE

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