GIS-based potential assessment and scenario analysis for integrating geothermal heat pumps technologies in urban energy systems

Alejandro Zabala Figueroa, Wided Medjroubi, Alaa Alhamwi
German Aerospace Center (DLR), Institute of Network Energy Systems
alejandro.zabalafigueroa@dlr.de

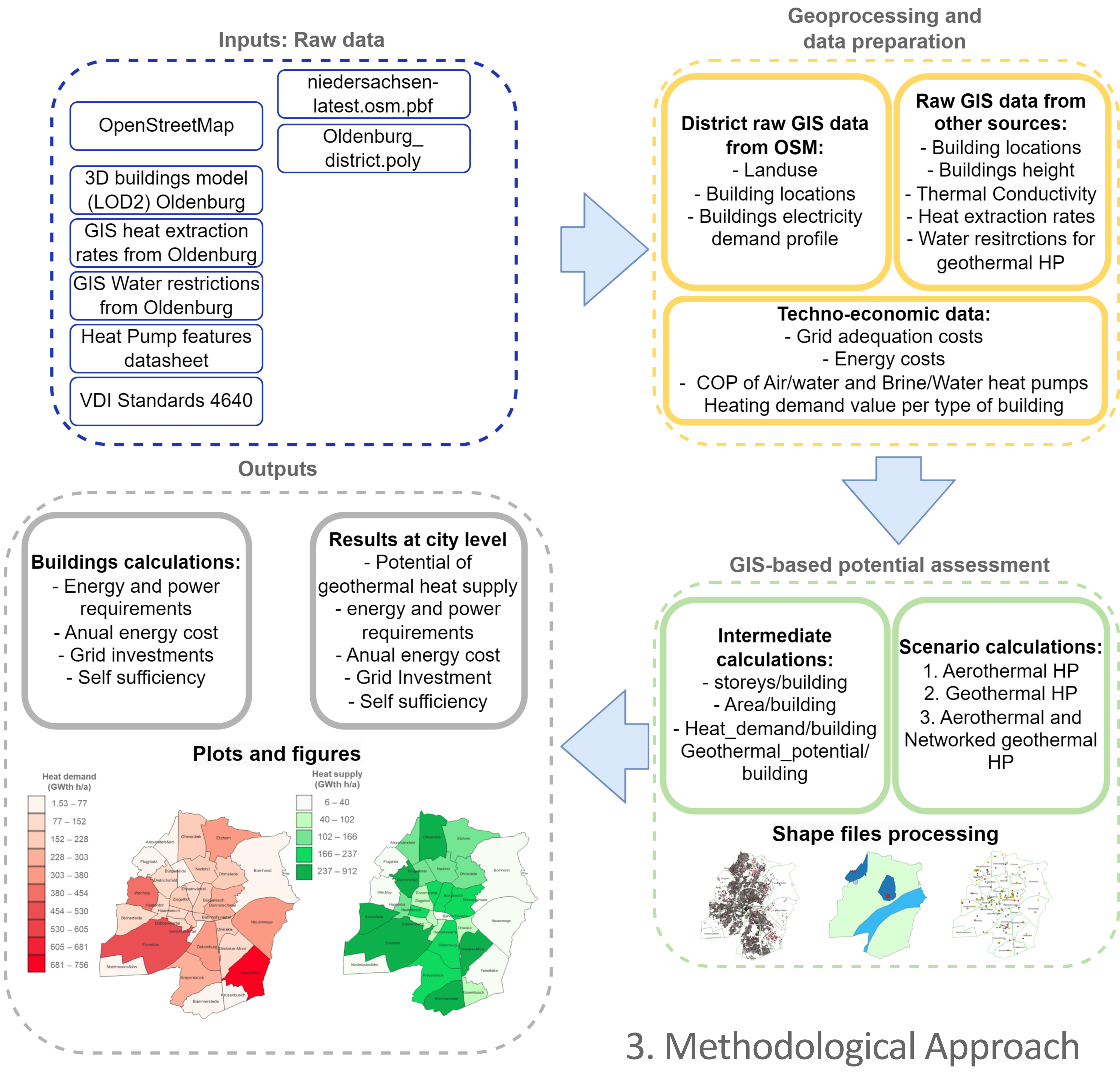

Fig. 1: Scope and modelling approach.

1. Introduction

Almost 80% of EU residential energy is used for heating, primarily from fossil fuels, causing high CO_2 emissions.

To decarbonize heating in cities, ground source (GHP) and aerothermal heat pumps (AHP) is investigated in this work.

2. Research Questions

- What type of shallow geothermal energy system (SGES) is most suitable for cities?
- How to evaluate the potential of geothermal energy in urban areas using open source data sources?
- Could SGES reduce the pressure on the power distribution grids in cities?

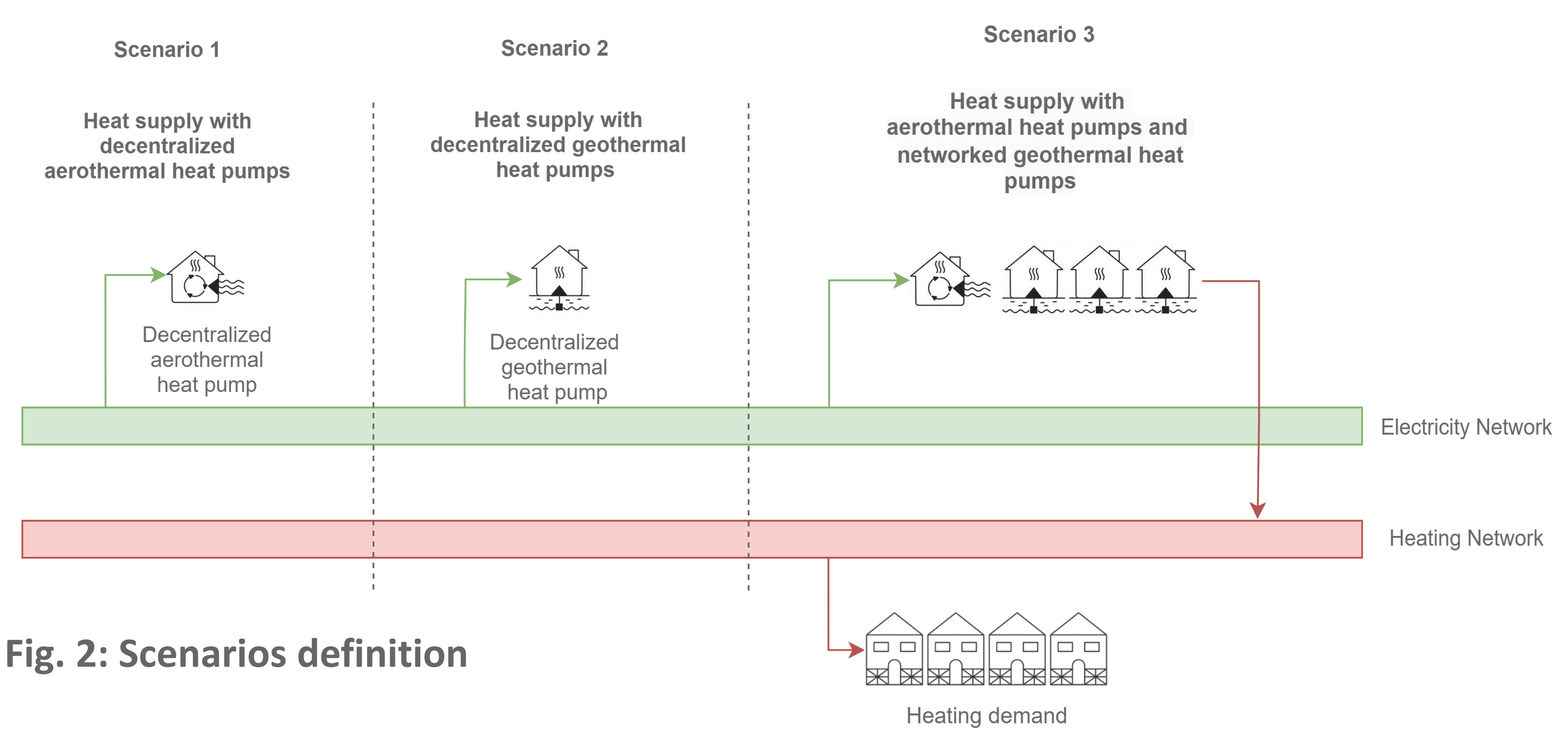

Fig. 2: Scenarios definition

3. Methodological Approach

There were three main sources of data for the use-case city of Oldenburg (Fig. 1):

- georeferenced data of the city infrastructure (buildings and their type).
- georeferenced datasets for heat extraction rates (heat potential) and water restrictions.
- A database of heat pump models for coefficient of performance and references to VDI standard 4640.

Three scenarios were under investigation (Fig. 2):

- Heat demand supplied by AHP.
- Heat demand supplied by decentralized GHP.
- Decentralized AHPs where geothermal energy isn't permitted and networked heat pumps up to 400m depth.

4. Results

Results shows Borehole Heat Exchangers (BHEs) are highly efficient at $2.2m^2$ per kilowatt using just 5% city footprint.

In contrast, basket collectors require 11%, and horizontal collectors 57% of space.

The increased electricity demand across building types (Fig. 3). For 2400 hours annually, AHPs raise electricity demand by 300%, mainly affecting commercial buildings. GHPs increase demand by 170%, satisfying 75% of city heat demand due to GHP installation constraints. Networked GHPs meet 100% of demand, raising energy use by 174%, but reducing strain on commercial and other building networks, and redistributing it on residential grids.

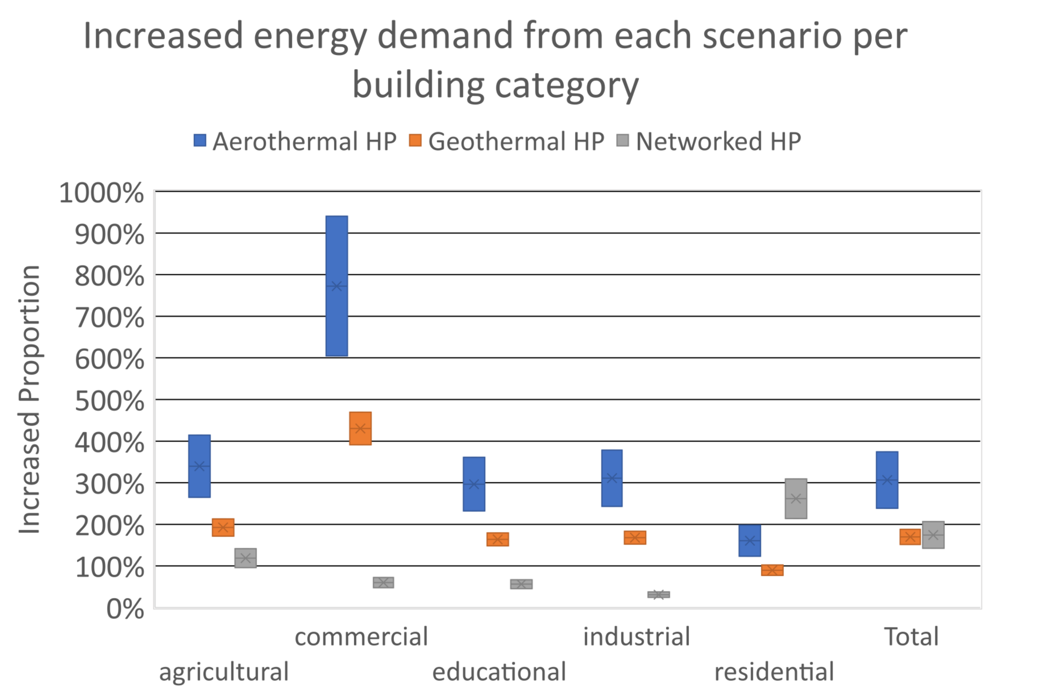

Fig. 3: Increased electricity demand for each scenario due to heat pumps installation

Conclusions and Outlook

- Open source data enables modeling building heat demand and estimating heat supply with shallow ground source heat pumps.
- Borehole heat exchangers, with a 2.2 m^2/kWh surface area, are optimal for urban geothermal energy systems.
- Proximity to groundwater is the most relevant constraint for the use of GSHPs. 24.6% in Oldenburg.
- Compared to aerothermal heat pumps, networked ground source heat pumps could avoid an average growth of the electricity grid of 180%.
- Better estimation of heat demand based on building types are needed.

DLR