

Supplementary Information for

Shallow geothermal heat recycling as a sustainable and just heating opportunity

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All Codes written by V.Dohmwirth

file name	titel	description	data needed
GEE-1-census data https://code.earthengine.google.com/b4b4f8d02d579fc7b481de98c3d3ad2b	Code to prepare census 2022 date for processing	This Google Earth Engine (GEE) code processes demographic data for Dresden and creates raster images and statistics for the individual districts	in this case: Census data from 2022 Germany, can be found here: Eine neue Datenbasis für Deutschland - Zensus 2022

GEE-2-status_quo https://code.earthengine.google.com/210aabf8e7770b1a82559fb3904e0dfd	Code to analyse the status quo scenario	This GEE code performs a comprehensive geothermal analysis for the city. The main steps are: 1. Gathering geodata, water table and groundwater temperature analysis, implementing land use and urban structure, 2. Calculating heat accumulation and heat flow, Calculation of stored heat energy and heat flows from various sources, e.g. tunnels, buildings, district heating systems, calculating technical Geothermal potential, getting available space for BHE installation 3. Analysis of heating requirements based on living space and heating energy consumption 4. Data export	we used: - GWT und water table from the Municipality of Dresden (not allowed to share) - Tunnels, Water protection areas, Geothermal extraction rate in 100m depth, Elbe river outline, districts (https://opendata.dresden.de, Themenstadtplan Dresden : powered by cardo.Map) - Land cover by Corine Urban Atlas 2018 (Urban Atlas — Copernicus Land Monitoring Service) - Building footprints (Downloadbereich Hausumringe - Offene Geodaten - sachsen.de) - Air temperature data by DWD (Index of /climate_environment/CDC/grids_germany/hourly/hostrada/air_temperature_mean/) - q_up from Davis (2013): Global map of solid Earth surface heat flow (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/ggge.20271) - other data and values can be found in supplementary materials of the paper - living space/ha from census data from 2022 Germany (Eine neue Datenbasis für Deutschland - Zensus 2022)
GEE-3-other_scenarios https://code.earthengine.google.com/9fd568fa4f95b58948946dd61a9ad616	Code to analyse future scenarios	same as GEE-2-status_quo, but for „recycled“ condition	- SSP air temperature projections from CMIP6 (CMIP6 climate projections)

GEE-4-SusS https://code.earthengine.google.com/8d21fc3ad66a8858041aca5a2d138561	Code to calculate different SusS	The GEE code examines how much of the heat demand can be covered under the various sustainable heat supply scenarios. It shows the suitable areas for geothermal installations and the number of people living there. The results are exported.	
GEE-5-preparation_for_Python https://code.earthengine.google.com/9501b391b0c1b31a5e8670f371d21223	Code to prepare all data for further Python analysis	The GEE code creates a combined data table with demographic and scenario parameters for each district.	
Python-1-CO2_tax	Code to calculate payback time and fair CO2 price	The python codes calculates the payback time of geothermal systems in comparison to gas heater systems as a function of time with different variables that change differently depending on the scenario.	
Python-2-SusS_and_demography	Code to analyse the prepared data from GEE	The python code analyzes whether various demographic factors correlate with sustainable geothermal potential. The visualizations help to identify trends and patterns in the data.	

The codes should be run in chronological order. Code 1- 5 are Ccodes for Google Earth Engine and code 6 and 7 are codes for jupyter Notebook.

Google Earth Engine codes are linked to the authors account.