EGU21-13411, updated on 19 Jan 2022
https://doi.org/10.5194/egusphere-egu21-13411
EGU General Assembly 2021

Assessment of hybrid urban renewable energy potential through sector coupling of photovoltaic electricity and geothermal heat

Alina Walch, Romain Sibuet, Roberto Castello, and Jean-Louis Scartezzini
EPFL, ENAC, LESO-PB, Lausanne, Switzerland (alina.walch@epfl.ch)

To fulfil ambitious targets for reducing CO_2-emissions in the building sector, the design of new neighbourhoods or the retrofitting of existing buildings requires an increasingly high use of renewable energy (REN). The coupling of heat and electricity in hybrid energy systems hereby plays a key role, as it allows to cover the needs of both sectors using renewable sources. Existing case studies of hybrid energy systems for individual buildings or neighbourhoods are often highly specific to a given location, and it is difficult to draw generalisable conclusions. This work hence aims at the development of a hybrid energy systems model based on large-scale databases of renewable energy potential with high spatial and temporal resolution, in this case for Switzerland. The resulting model may be used to obtain comparable results for case studies across the country or scaled up to the national level. For this, our approach integrates national-scale databases of hourly solar photovoltaic (PV) potential [1] and ground-source heat pump (GSHP) potential [2] for individual buildings with their modelled heat and electricity demand.

The presented work consists of three steps. First, hourly energy demand for heat and electricity of the residential and service sectors is derived for the entire Swiss building stock. The hourly demand model combines a top-down modelling of annual energy demand with a bottom-up mapping of hourly demand profiles. Second, the energy demand profiles are matched with the renewable energy potentials in hybrid energy systems, at the scale of individual buildings and neighbourhoods. We further add flexibility options to these systems, such as thermal energy storage. Third, the size of the renewable technologies and the storage options are optimised such as to maximise the autonomy level of the resulting hybrid energy systems. The autonomy level is obtained through the modelling of the system dynamics at monthly-mean-hourly temporal resolution, i.e. at hourly resolution for a typical day per month. This reduces the computational complexity of the approach and assures its scalability to the national level.

The above workflow is tested on a neighbourhood in Geneva, Switzerland, and the resulting optimal system configurations are compared across different building types in the residential and service sector, and for different shares of REN generation. We show how different system configurations, such as the combined use of PV and GSHPs, as well as the addition of flexibility through the use of a thermal energy storage, impact the self-sufficiency and autonomy level of buildings and neighbourhoods. While the presented work focuses on one neighbourhood only, future extensions will aim at applying the model to the Swiss national scale using all data in the

national REN databases. This will allow to compare the feasibility of different system configurations with high REN shares across the country.

[1] Alina Walch, Roberto Castello et al. 'Big Data Mining for the Estimation of Hourly Rooftop Photovoltaic Potential and Its Uncertainty'. *Applied Energy* 262 (2020).

[2] Alina Walch, Nahid Mohajeri, et al. 'Quantifying the Technical Geothermal Potential from Shallow Borehole Heat Exchangers at Regional Scale'. *Renewable Energy* 165 (2021).