Dynamic heat map as a part of the regional energy transition

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Abstract

Heat maps show the heat and cold demand of residential, commercial and industrial buildings as well as the waste heat from industry. They combine these two aspects in order to plan new heating/cooling networks. By planning the thermal energy supply in a central way, the efficiency of the energy production and the overall exergy rate are also increased. The paper will present the methods of modern web-based heat mapping with a user oriented interface in the example of Saarland region, Germany. An overview of the heat demand survey including development of building and settlement typology by clustering as a base of the heat mapping will be given.

Keywords: Heat map, heat demand, clustering, building and settlement structure

1. Introduction

The Federal Government of Germany will clearly miss its target of reducing GHG emissions by 40 % by 2020 compared to 1990. One reason for this is that the promotion of renewable energies, in particular photovoltaics and wind energy, has focused for years on electricity generation. Heat and transport, on the other hand, were neglected in the political debate until a few years ago. However, this has changed. In view of the required sector coupling, heat supply is playing an increasingly important role - especially in public perception. The significance of heat for the energy turnaround can be seen from the following statistics:

1. More than half of the final energy consumption in Germany is consumed by heat applications (BMWi 2018). They are responsible for about a quarter of energy-related GHG emissions.
2. Share of renewable energies (above all biomass) in final energy consumption for heat is 13.4 % – but in electricity consumption is the share only 31.7 % in 2016 (BMWi 2019, AGEE-Stat).

An almost unsolvable task in the near future appears to be the reduction of space heating demand (28 % of final energy consumption in Germany, BMWi 2018). An annual renovation rate of two percent would be necessary for the national goals. Recently it is only around one percent per year (Dena 2018). This raises the question of alternatives – at least for a transitional period. In Germany, these are currently mainly seen in transformation of the heat supply. Fossil energies, such as fossil heating oil and natural gas, are to be replaced by power-to-gas, power-to-heat or the use of waste heat. The focus is no longer on the individual building, but on the search for the optimal solution for whole quarters (e.g. heating network). This requires a rethink in the planning and implementation of heat projects. The first approaches to municipal heat planning have emerged in Germany (cf. e.g. StMUG 2010). These are usually limited to the preparation of simple heat maps, which can be used to show local potentials, e.g. for waste heat utilisation (IZES 2018). In the EU Efficiency Directive, such heat maps are also mandatory (Directive 2012/27/EU).

2. Objectives

The Ministry of Economics of the Saarland (Germany) has set itself the goal of creating an uniform and comprehensible data foundation for the systematic identification of concrete approaches enabling to increase the share of renewable energy supply and industrial waste heat by creating a state-wide heat map and making this data available to the actors involved in the heat turnaround. Thereby, it is important that the actors of the heat market (e. g. consulting engineers) have dynamic access to the relevant information in the geoportal.

3. Methodology

A sustainable heat planning requires balancing of today's heat demand as well as its future development caused by energetic restoration. For this, among others, the location, ownership and structural condition of the buildings are of importance. In order to take all this into account when estimating the development of future heat demand, the settlement structures were hereby, for the first time, taken into account. The methodology applied is summarised below. A detailed description can be found in IZES (2016).

3.1. Typological differentiation of buildings

In a first step, the building stock in Saarland was classified according to the type of building:

- Main or auxiliary building
- Building use (as e.g. residential buildings or functional building such as a school)
- Building class according to the Saarland building regulations (single-family house, small and large apartment house, high-rise building)
- Age of building class

Primarily the Saarland ALKIS® and ATKIS® data set, the 3D building model and the age of buildings according to census were evaluated. Company databases and other online sources were also included. A separate iterative approach was developed to determine the age structure of the buildings, which assigns the age of the building on basis of spatial as well as building and parcel parameters.

3.2. Calculation of buildings' heat consumption

Based on the building typology developed in the course of the European TABULA project, a specific value for heat demand was assigned to the residential buildings (Loga, Diefenbach, Stein 2012). Alternative parameters were used for non-residential buildings (BMVBS, BBSR 2009). By multiplying the values by the building area, an estimated heat requirement could finally be determined for each building. In addition, a maximum potential for future energetic restoration was determined.

3.3. Determination of energy savings and waste heat

In order to estimate how the heat demand will change until 2025 and 2035 resp. how much of the existing saving potentials will realistically have been realised by then, assumptions were made for each type of settlement with regard to historic activities of energetic restoration. A total of 13 settlement types were differentiated (from the block structures of the Wilhelminian style to the one- and two-family house development in the recent years). In addition, the population and living space development forecast for the Saarland municipalities was taken as basis. Table 1 shows the settlement types identified and their numerical distribution in Saarland.

Table 1. Identified types of settlement in Saarland

No.	Type of settlement	Number
1	Estate of terraced houses after 1957	315
2	Dense construction before 1958	1,365
3	Block building before 1958	465
4	Scattered development before 1969	2,395
5	Detached houses after 1983	985
6	Detached houses (1958-1968)	1,840
7	Developm. on main roads before 1964	4,455
8	Semi-detached houses (1949-1968)	755
9	Detached houses (1969-1983)	1,780
10	Open building	690
11	Developm. on main roads after 1963	665
12	Large housing	280
13	Skyscraper construction	30

Building on this, the settlement areas surrounding sources of waste heat were investigated systematically with regard to their economical practicability. Besides, heat transport costs were used to rank the heat network approaches.

4. Results

The heat demand in Saarland is around 10.9 TWh/a. It is expected to fall by around 10% to 9.9 TWh by 2035 as a result of the energy efficiency measures. But only small savings are expected in the residential buildings on main roads, which are frequently found in Saarland. Their share of the total heat demand even rises slightly from 18.6 to 19.5 % during the period considered.

The spatial join of heat demand and existing waste heat shows that in Saarland a large number of areas are suitable for district heat supply. Focusing on the 60 most confident waste heat sources, more than 13,000 of the 300,000 buildings could be supplied almost CO2-neutrally by heat from these existing heat sources alone. The current and forecast heat demand of the 16,000 Saarland settlement areas in total can be viewed and downloaded in absolute figures and as heat density from the Saarland geoportal. The individual data layers can be combined as desired (dynamically). In addition, there is access to all background data as well as the detailed results of the investigated heat network approaches.

5. Outlook

The heat map is a first step for the Saarland towards a sustainable heat supply. Further steps must now follow. Accompanied by the Ministry of Economics, the above-mentioned players will now be contacted personally and confronted with the results of the heat mapping. The aim of this is specifically to initiate projects for waste heat utilisation and to promote these exemplarily in the sense of best-practice examples. Simultaneously, the methodology presented is currently being applied to four municipalities in Luxembourg. Within this framework, additional data sources are assessed for their usefulness for heat mapping, with the aim of improving the quality of the results. In addition, together with the users in the Luxembourg municipalities, the possibilities of using the heat map as an instrument for energy planning and balancing will be examined. The results are also extremely important in the context of the phase-out of coal. Existing district heating networks in Germany are often fed by coal-fired power plants. These networks must be rehabilitated and converted for the use, for example, of industrial waste heat. The planning for this is facilitated by heat maps. In order to improve data quality, the Federal Ministry of Economics and Technology is funding the DynamiKol project started in June 2019. The project will research possibilities to improve balancing heat demand by using citizen science approaches.

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