Bottom-Up and Top-Down Heat Demand Mapping Methods for small Municipalities, Case Gllogoc

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ABSTRACT

The identification and spatial distribution of heat demand for space heating is of high importance for the planning and design of district heating systems because around 70-80% of total final energy consumption by the household sector is consumed for space heating purposes. The aim of this research is the quantification and validation of heat demand distribution within a small municipality using a newly developed Bottom-up and Top-down heat mapping method. The Bottom-up mapping method is based on building features such as surface floor area, building height, building use and the share of the heated area while the top-down mapping method relies on energy balances and population distribution densities. These mapping methods are based on a GIS analysis of heat demand with high spatial resolution grids 100 m × 100 m. Two bottom-up scenarios have been created, one of which overestimate and the other which satisfy the actual heat demands of the buildings and the results of both are compared with the top-down analysis to quantify the impact of the assumptions and input data on the final result.

KEYWORDS

Heat demand, Heat mapping, Bottom-up, Top-down, GIS, partially heated areas, etc.

Highlights

- In this article, a new Geographic Information System based bottom-up model for mapping the heat demand is developed,
- Validation of the model with existing heat mapping methods has been done,
- The model shows the actual heat demand of buildings partially heated,
- The results of heat demand are shown spatially in 100m × 100m grids,
- The model is tested in the Kosovo municipality case, but the method can be applied anywhere.

INTRODUCTION

Europe have set the targets to reduce the annual greenhouse gas emission by 40% in 2030 and 80% for 2050 compared with 1990 levels [1]. Many research studies addressing the CO_2 emission reduction goals through modeling analysis of energy systems using different approaches and tools are carried out so far. It was pointed out that the final energy use for space heating plays a significant role in final energy consumption by residential and commercial end-users. According to the International Energy Agency (IEA), 31% of primary energy supply worldwide is converted into thermal energy respectively heat [1]. Even a higher share of final end use heat demand applies to Kosovo energy system case. The share of residential energy consumption in the total final energy end-use is 31%, and 10% for services (commercial and public consumers). 69% of total final energy use by residential end-use account for space heating, and 78% for services. In reviles the fact that the share of energy consumed for space heating in total final country energy end use for the year 2015 was 29.2% [2]. A better understanding of the space heat demand mapping process can contribute to more accurate modeling and planning strategies that accelerate the reduction of greenhouse gas emission and decarbonization of energy systems. Research [3] established a model for estimating the thermal end-use demand in the building stock of Newcastle upon Tyne. The main aim and conclusion is that unless knowledge and model estimating is available at an appropriate level, future UK local energy infrastructure planning will not be effective. Figure 1 shows the reviewed heat demand mapping approaches and the methodology applied in this research. The top-down approach stands for aggregated data, while the bottom-up approach for disaggregated data. The top-down heat mapping category emphasizes the heat demand widely, while the bottom-up category features the selection of specific thermal energy demand annually and building features. Inputs used in top-down models are energy consumption data, land use data, population distribution maps, while the outputs are spatially aggregated heat demand, limited spatial resolution and large scale application. It requires very few data and the modeling process does not take too long. In contrast, in bottom-up approaches, input data used are building features, building topography, specific energy consumption. These data are not available for any location which limits the application of this method worldwide.

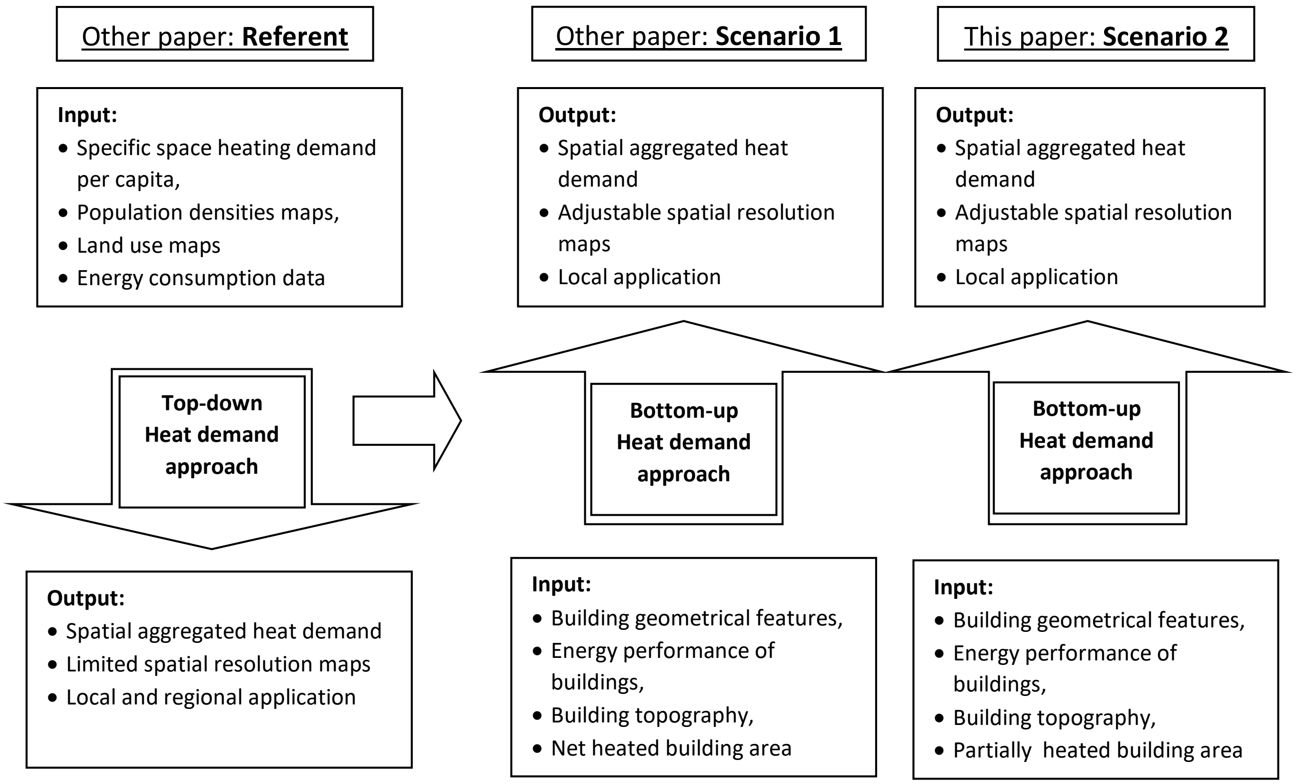

Figure 1**.** Top-down and Bottom-up approaches that are used for modeling spatially space heating demand.

Furthermore, the time consumed for data collection and proceeding takes a quite long time, for that purpose this approach is mostly used locally. Bottom-up is a more utilized approach in studies researching the expansion of DH systems [4] [5] [6] [7] [8] thermal energy planning and modeling [9] [10], [11],[12] analyzing different configurations of DH and its distribution heat losses [13], utilization of waste heat resources [14], [15], [16], [17] integration of renewable technologies in DH [18], [19], [20]. In contrast, the top-down approach is generally used for heat mapping in large area locations and is much more useless for small area locations compared with the bottom-up approach. The resolutions of maps obtained from top-down approaches are dependent on other spatial provided datasets, which is not the case with bottom-up mapping which allows adjusting maps with the desired resolution.

Kavgic et al. presented research reviewing the description of these mapping approaches and bottom-up modeling technics for different building stocks [21] to identify the energy consumption in the residential sector. Berger et al. presented a novel top-down methodology for the determination of heat demand for space heating as a function of usage and time using aggregated load data on heat demand, with a focus on residential space heating [22]. Results obtained identified the aggregated heat demand curve suitable for usage in energy system modeling. Gils et al. assessed the energy demand for space heating and hot water in the residential and commercial sectors spatially using a top-down approach that was based on high-resolution population distribution and land use data for USA [23]. Gils et al. assessed a top-down newly developed method for quantification of country-specific heat demand DH potentials for different heat demand levels across Europe [24]. A bottom-up approach for estimating spatially the heating demand of residential building stock for the Valle d'Aosta region was shown in [25]. The results obtained have shown the estimation of the geo-referenced heating demand of the residential buildings for the case study area (almost 42,000 buildings), and the development of a methodology that can be applied at different scales. However, the methodology overestimated the total heating demand, the researchers concluded that new data available can improve the quality of the results obtained. A model that characterizes the energy performance of the built environment at a territorial scale was developed in [26]. It followed a simplified procedure that took into account: data available in the Energy Certificate of Buildings database, data about the age of the buildings and the energy reference surfaces available in the official statistics database. Wyrwa et al. analyzed a bottom-up approach for calculation of useful heat demand for space heating and hot water for the city of Krakow that was aggregated in a grid with 100 m × 100 m spatial resolution to deliver a heat demand map for 21 buildings [27]. Results showed that the residential buildings, respectively one and multifamily houses have the highest share of overall space heating demand compared with other building categories. Johannes et al. gave a similar study based on the bottom-up approach that generated a raster aggregated layer grid with 200 m × 200 m of the annual heat demand for space heating and hot water in [28]. Petrovic at el. presented a model for determination of heat demand, possible heat savings and associated costs in the Danish building stock in [29]. The obtained results were stored in a GIS heat atlas for entire Denmark. Pampuri et al. developed a method for identifying areas that are potentially suitable for DHS by taking heat density as the main metric [30]. Results were presented using a GIS interface.

This paper and the presented method focuses on the space heating estimation spatially for mix building categories. The spatial heat demand modeling approaches Top-down and Bottom-up, is a well-studied field, however, there is no research that compares the results obtained when applying both methods especially in developing areas. Thus the primary aim of this paper is to answer the research questions:

- *Is there a difference in results between bottom-up and top-down heat demand mapping approaches?*
- *What is the role of partially and fully heated areas in the method calibration?*

Bottom-up approaches for estimation of spatially building heat demand where buildings were heated to their net areas were shown in all research papers reviewed. In contrast, it was found that there is a gap on research available published, which addresses the method of the bottom-up heat demand mapping for under-developing city area locations with partially heated areas. In addition to that, the aim of this research is to validate a bottom-up heat mapping method with partially room heating that can be used for assessing the spatial distribution of annually aggregated heat demand maps in developing cities with a lack of available data. The origin, as well as exemplary case study of the presented data and research, is a small city in Kosovo. The methodology to be derived can be applied to any country.

METHOD

Identification, quantification, and allocation of heat demand in developing urban area is of high importance for carrying out utilization potential of district heating systems, creating hourly heat demand curves for each municipality, that can be used by other energy simulation and optimization tools, mapping of energy resources and sinks, mapping of waste heat resources, comparing such results with other methods used for the same purposes, among others. Generally, there are two most used methods for assessing the heat demand mapping for countries and cities, so-called Top-down and Bottom-up. Top-down heat demand mapping is used for assessing the country heat demand, while the bottom-up mapping mainly is used for assessing the mapping in municipalities, respectively mapping of city area locations. In addition to that, for assessing the utilization analysis of district heating potential in cities, the bottom-up mapping approaches have been used, since the method itself has taken into account current building features as well as the climate effects of a particular location.

The method of mapping assessed in this article consists of two main parts, first the quantification of heat demand using the mapping results of a top-down approach and then the validation of bottom-up mapping approaches with the aim of two estimated scenarios. A detailed description of the discussed methods as well as the data used for established scenarios is given below.

Top-down Heat Demand Mapping

A top-down heat mapping method was conducted for estimation of the overall space heat demand consumed by the residential and commercial buildings using the datasets of population distribution densities and the statistical data of the annual energy balances. Only the heat demand consumed for space heating was considered excluding heat for hot water preparation and industrial heat. Data for the annual energy consumption by end-users in a country level as well as data for the heat consumed for space heating were taken from the International Energy Agency for the reference year 2015 [1]. Data on the fuel shares used for heat generation is only available for residential space heating and hot water production for some countries, while the data for population distribution densities is available online for any country [31]. For that reason, this methodology can be applied to any country if the annual energy balance is known.

The total thermal energy consumed by residential buildings is calculated with the following equation:

$$E_{tot}^{res} = E_{coal}^{res} \cdot \eta_{coal} + E_{oil}^{res} \cdot \eta_{oil} + E_{biomass}^{res} \cdot \eta_{biomass} + E_{elec.}^{res} \cdot \eta_{ele.-thermal} + E_{DH}^{res} \tag{1}$$

E_{coal}^{res}, kWh – Coal energy consumption by residential buildings;

E_{oil}^{res}, kWh – Oil energy consumption by residential buildings;

$E_{biomass}^{res}$, kWh – Biomass energy consumption by residential buildings;

$E_{elec.}^{res}$, kWh – Electricity energy consumption by residential buildings;

E_{DH}^{res}, kWh – District heat consumption by residential buildings;

η_{coal} - The efficiency of conversion of chemical energy of coal into heat;

η_{oil} - The efficiency of conversion of chemical energy of oil into heat;

$\eta_{biomass}$ - The efficiency of conversion of chemical energy of biomass into heat;

$\eta_{ele.-thermal}$ - The efficiency of conversion of electrical energy into heat;

Furthermore, the share of final thermal energy consumption for space heating, by residential buildings, was obtained by multiplying a factor of the percentage of final energy consumed for space heating with the overall energy consumption from residential end-users [1]:

$$E_{thermal}^{res} = E_{tot}^{res} \cdot a_1 \tag{2}$$

Where: a_1 - is the factor of the percentage of total final thermal energy used by residential buildings for space heating purposes [32].

Similarly, the thermal energy used for space heating by commercial buildings is given by:

$$E_{tot}^{com} = E_{coal}^{com} \cdot \eta_{coal} + E_{oil}^{com} \cdot \eta_{oil} + E_{biomass}^{com} \cdot \eta_{biomass} + E_{elec.}^{com} \cdot \eta_{ele.-thermal} + E_{DH}^{com} \tag{3}$$

E_{coal}^{com}, kWh – Coal energy consumption by commercial buildings;

E_{oil}^{com}, kWh – Oil energy consumption by commercial buildings;

$E_{biomass}^{com}$, kWh – Biomass energy consumption by commercial buildings;

$E_{elec.}^{com}$, kWh – Electricity energy consumption by commercial buildings;

E_{DH}^{com}, kWh – District heat consumption by commercial buildings;

The conversion efficiencies presented on equation (3) are the same as those described in residential buildings.

The final thermal energy consumed by commercial buildings is written with:

$$E_{thermal}^{com} = E_{tot}^{com} \cdot \left(\frac{a_2 + a_3}{2} \right) \tag{4}$$

Where: a_2 and a_3 - are the percentage factors of total final thermal energy consumed by commercial end-users (public and private buildings) for space heating purposes [32].

Then, the total heat demand for space heating accounting for both residential and commercial building is summed up with the following equation:

$$E_{tot}^{thermal} = E_{thermal}^{res} + E_{thermal}^{com} \tag{5}$$

Specific heat demand for space heating per capita was obtained by dividing the overall country space heating demand consumed by residential and commercial buildings with its capitals with the following expression:

$$e_{thermal}^{capita} = \frac{E_{total}^{thermal}}{n_{capitals}} \tag{6}$$

In order to acquire a heat density map in a Geographical Information System tool, the per-capita demand values have to be multiplied with a grid that represents the distribution of residential and commercial consumers. For the residential and commercial heat demand consumers, the per-capita heat demand (6) in each grid cell is multiplied with the number of inhabitants of the corresponding cell with 250 m × 250 m. In this way, a distributed heat demand map was created for city area location with the use of a Quantum Geographical Information System tool QGIS [33]. Data on the distributed population densities in the resolution of 250 m × 250 m were taken from the reference [31] and multiplied with the specific heat demand per capita that was estimated by following the above-described procedure (6). Similarly, the heat demand distribution map for any country can be determined using this top-down approach.

Bottom-up Heat Demand Mapping

The bottom-up mapping method mainly is used for assessing the heat demand mapping in municipalities, respectively mapping of city area locations. The method itself takes into account building features as well as the climate effects of a particular location. In order to quantify the heat demand used for space heating and its heat demand allocation, a heat matrix is created. This matrix was used for assessing the heat demand mapping process through the use of calculation tools QGIS 2.18.19 and EXCEL in 2016. Bottom-up heat demand mapping method consisted of the main three steps:

Mapping of building area location,
Mapping of building floors,
Mapping of building categories,

Depending on these input information layers, a gross area matrix is created. Such a matrix then is used for creating the heat demand map when multiplying the net building areas with the specific heat consumption of buildings. In that way, the heat demand consumed by buildings spatially has been estimated. Afterward, the heat demand consumed by residential, commercial, public buildings was aggregated spatially in 100 m × 100 m grids. Building categories of houses, houses without thermal insulation in external walls, apartments, offices, public and industrial buildings were assessed for the purpose of this research.

Because of buildings in developing area locations are not heated up to their net areas, application of actual mapping method for such area locations reviles with an overestimation of building heat demand. In order to validate the model with actual building space heating consumption two bottom-up scenarios have been developed, one of which that overestimate and the other which satisfies the actual heat demands of the buildings.

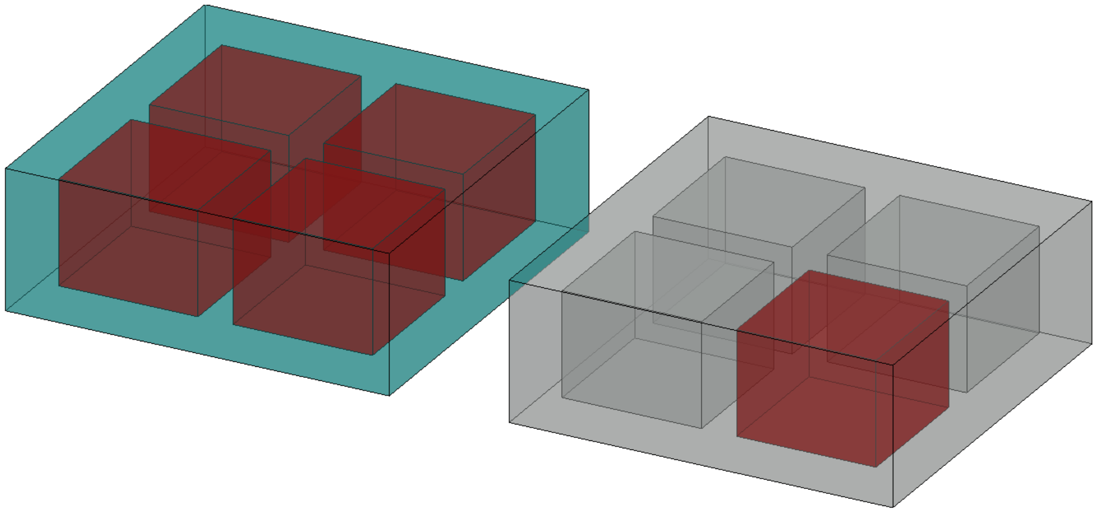

Figure 2. Houses being heated to their net area left side (Scenario 1) and houses partially heated right side (Scenario 2)

In the first scenario, all building categories are heated up to their net area, while in the second scenario buildings respectively houses with and without thermal insulation in external walls are heated partially (figure 2). In addition to that, this scenario assumes that expect houses all other building categories including apartment buildings, offices, public and industrial buildings, are heated up to their net area.

RESULTS AND DISCUSSIONS

As a case study for testing this method, three districts of Gllogoc municipality in Kosovo were selected. Building polygons areas were drawn manually using the plugin of Google Satellite in QGIS 2.18.19. Identification of the number of floors, building categories also is done manually by visual inspection of analyzed buildings, because of the lack of online available data. For other area locations, outside Kosovo, this can be done through the use of Google Earth Pro, or any other Geo portal tool that has the options to identify the buildings in a three-dimensional view.

In total, for the purpose of this research, 1940 buildings were analyzed and grouped into six categories. The survey accounted 1172 houses, 604 houses without thermal insulation in external walls, 106 apartment buildings, 5 offices, 43 public buildings including (schools, hospitals, and buildings of the municipality) and 10 buildings used for industrial purposes (including Feronkeli industry). Houses analyzed in actual study case are buildings that are built after the 2000, so they are quite new. Their external walls are composed by clay blocks with a thickness 25 cm, insulated with an insulation layer 5-10 cm and plastered on both sides with gypsum layers. The roof of the reinforced concrete slabs combined with hollowed clay elements is covered with titles. The floor is made of concrete construction with the final wooden flooring and ceiling with lime plaster. It was estimated by country energy auditors that their energy performance accounts for an annual specific heat consumption for space heating around 150 kWh/m^{2}year [34].

Other houses, also new constructed, (so called houses without thermal insulation in external walls) are made of clay blocks with a thickness 25 cm, plastered just from inner side. They do not have thermal insulation in external walls. The roof and the floor are the same as for insulated houses. For this kind of construction according to energy performance of actual building stock, the annual specific heat consumption for space heating is evaluated to be 262.5 kWh/m^{2}year [34]. Specific heat consumption for other building categories is taken from the paper [35], which is similar to those presented for buildings in Kosovo (Table 1).

Table 1. Building categories used in this survey[33][34].

Category	Specific heat demand in [kWh/m^2 year]	Number of buildings [-]
Houses	150	1172
Houses without thermal insulation	262.5	604
Apartment building	161.25	106
Offices	135	5
Public buildings	270	43
Industry	110	10

A similar mapping method can be used to assess the heat demand mapping for other small municipalities, but this way of assessing mapping is very time consuming and the quality of results strongly depends on datasets and assumptions adopted in the model. For validation of the model, two bottom-up heat demand maps have been created. In the second scenario with partially heated rooms for Gllogoc district, it was assumed the same share of heated rooms like Ferizaj district, because of the same building infrastructure. Similar results of heat room sharing in houses was obtained for other municipalities in the study [36]. Figure 3 presents the percentage share of partially heated houses for Gllogoc.. It can be noted that 43% of houses have installed heat providers just in one room, 22% in two rooms, 13% in three rooms, 4% in four rooms and 18% in more rooms respectively.

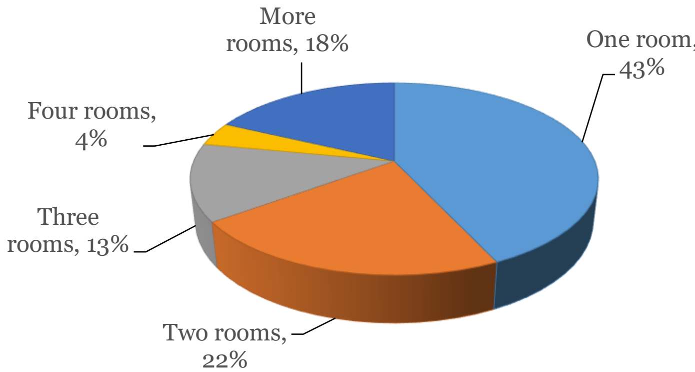

Figure 3. The share of partially heated house rooms in three districts of Gllogoc city.

From the pie graph of figure 4, it can be noted that when considering that all the buildings are heated to their net area, houses with and without thermal insulation will be the main heat consumers. In contrast, when considering the share of partially heated rooms in houses it was found that apartments and public buildings lead the heat consumption compared to other building categories figure 5.

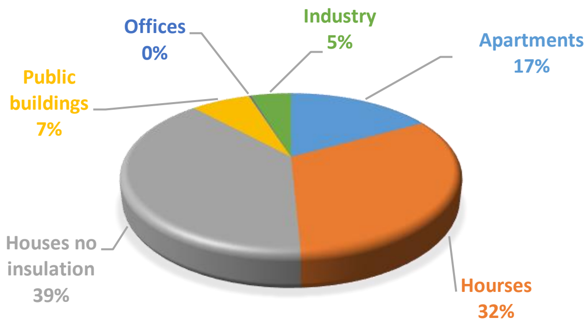

Figure 4. The share of classified buildings in overall estimated bottom-up heat demand mapping scenario (Scenario 1)

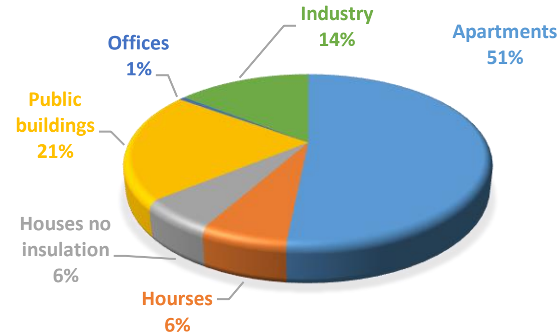

Figure 5. The share of classified buildings in overall estimated bottom-up heat demand mapping scenario (Scenario 2)

Figure 6 shows the gross area matric that is composed of three information layers, mapping of the floor areas, mapping the number of floors and mapping the building categories. The left map in figure 6, shows the building heated and not heated areas, while in the middle and right side maps, the buildings that were not being heated were excluded from the analysis. Such buildings included garages and cow farms among others etc. Two metrics showing the heat demand spatially for buildings that are being heated up to their net area and partially have been created and the results of both are presented in figures 8 and 9 respectively.

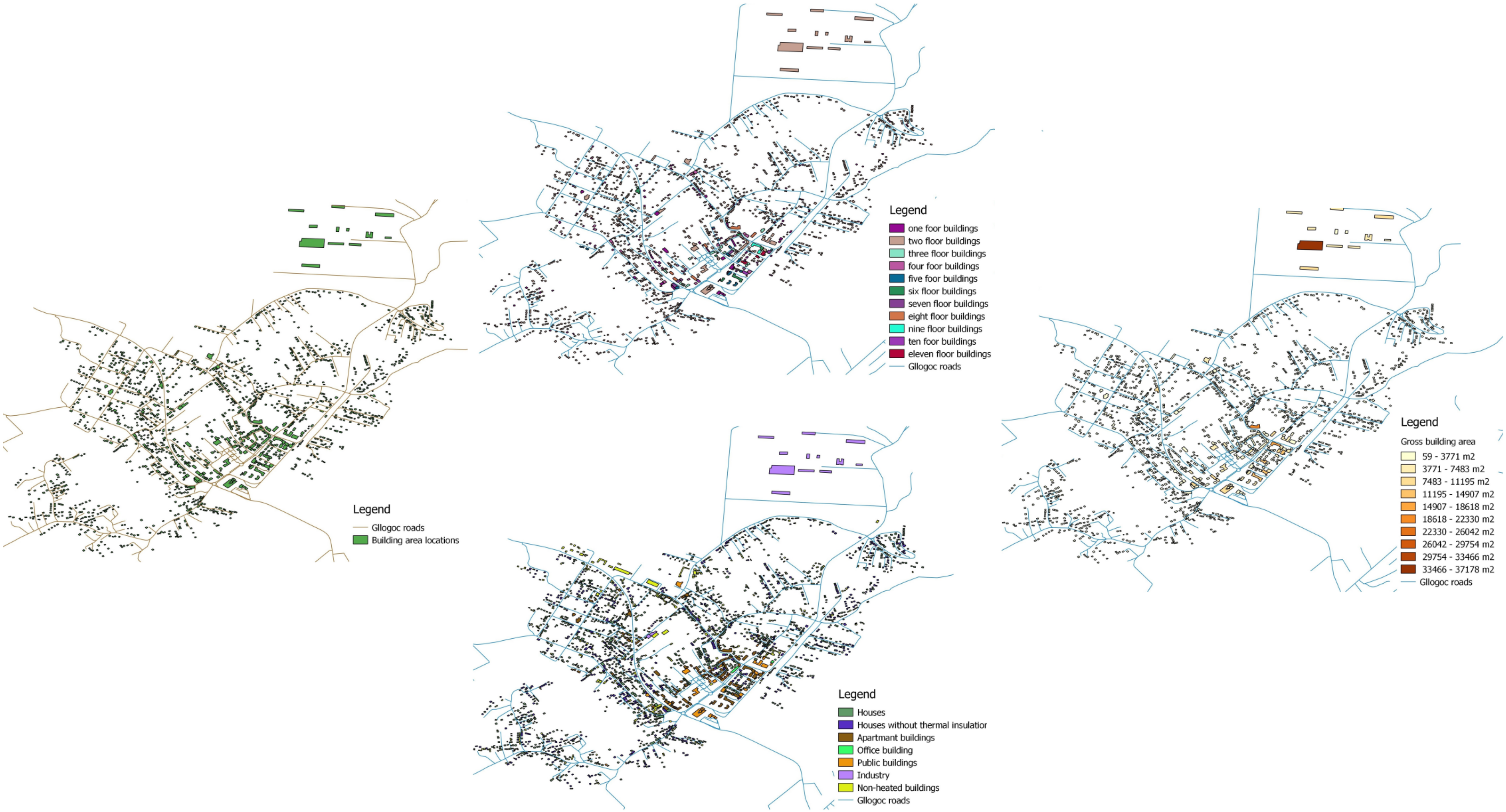

Figure 6. Gross area matrix. Step 1 – mapping of building area locations, Step 2 – mapping the number of floors, Step 3 – mapping the classified buildings, and Step 4 – mapping of building gross area.

A spatially-gridded useful heat demand distribution (heat demand map) for Gllogoc city using a top-down heat demand mapping approach, for the reference year 2015, is presented in Fig. 7. The grids are composed of 250 m × 250 m spatial resolution and each cell contains information, which can be observed as the thermal energy demand consumed for space heating annually in MWh. When summing up all heat demand load aggregated into those grids, it was found that the overall heat demand consumption in three districts of Gllogoc city accounts **53.138** GWh/annually.

The results of the top-down heat mapping approach displayed within Gllogoc city units (figure 7) might be useful information for the local stakeholders to identify the utilization of district heating potential for the assessed area location. In addition, that was not the objective of this work, therefore the top-down heat demand mapping results have been used to calibrate the heat demand consumed by buildings with the aim of two bottom-up heat mapping scenarios.

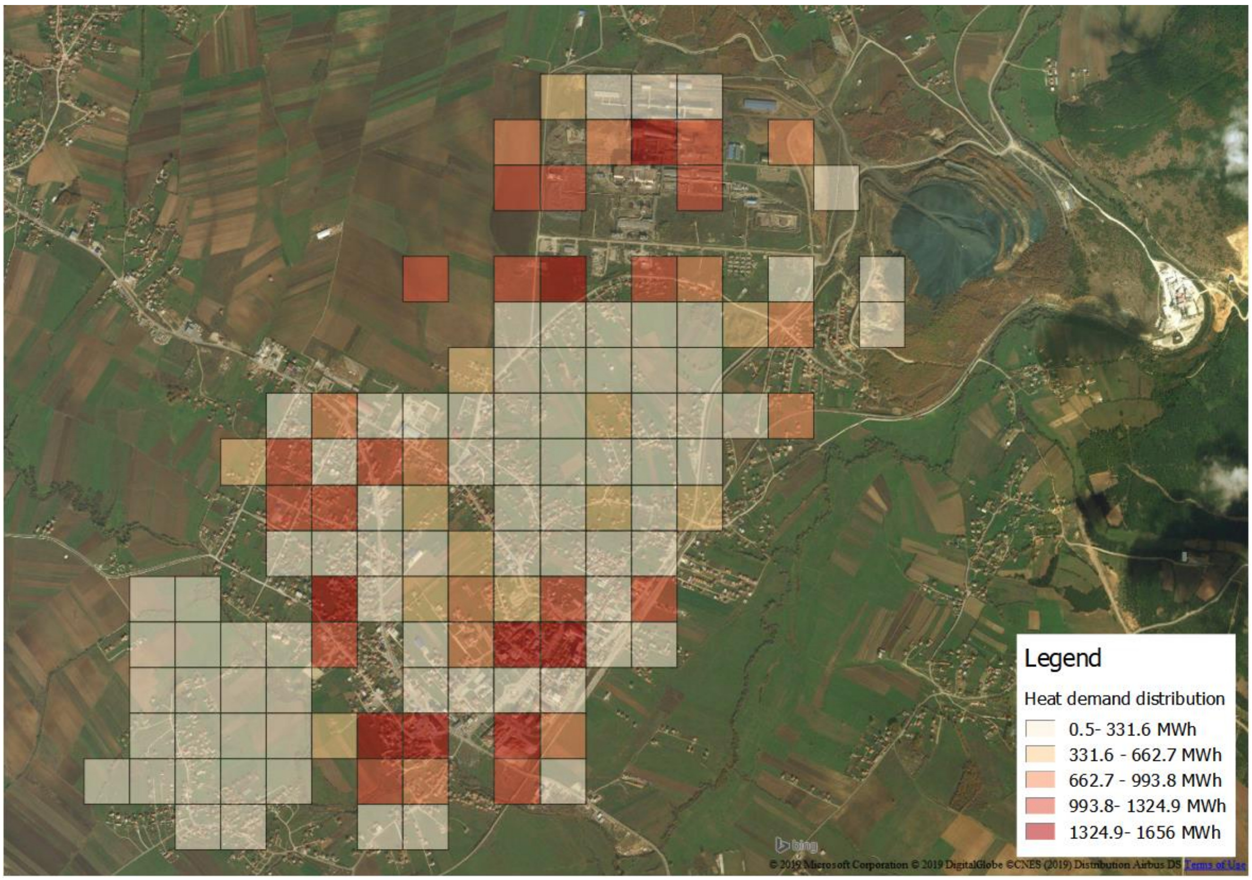

Figure 7. Heat demand distribution in Gllogoc city using top-down mapping.

It can be acquainted that this way of assessing heat demand allocation in small cities would not be suitable enough, due to that, the method itself has not taken into account building features and climate impacts. Furthermore, some grids have indicated quite high thermal energy consumption by residential and commercial end-users (dark red grids), even though there was not displayed any built-up area in those grids. This strengthens the conclusion that this way of assessed heat demand mapping is not appropriate for small cities, but it may work for counties as well as large urban area locations. In contrast, for better allocation of heat demand distribution in small cities, bottom-up mapping approach can be used.

In the first bottom-up heat mapping scenario assessed, all the buildings were heated up to their net areas. In figure 8, the obtained results of heat demand consumed by buildings and the heat demand aggregated on 100 m × 100 m grids for scenario 1 are displayed. In such a way, an overall heat demand **152.9** GWh/year by three districts of Gllogoc city was estimated, which outcome resulted to be an overestimation. The results of the first scenario revealed to be three times higher than the heat demand map assessed with the top-down approach.

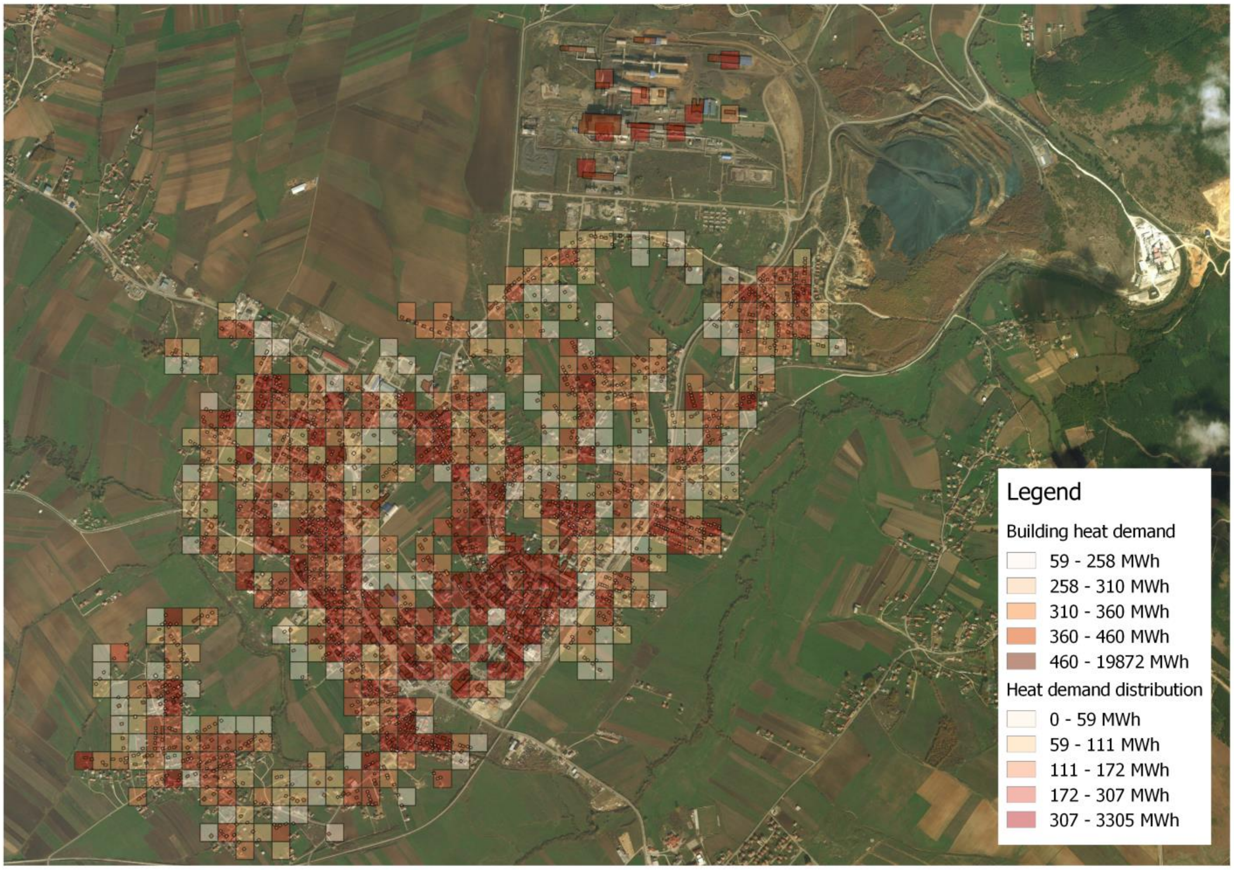

Figure 7. Heat demand distribution in Gllogoc city using bottom-up mapping (scenario 1).

Commonly, other bottom-up approaches presented in the literature review section, have been using the first scenario methodology for their validation, which was not the case with the current study. In scenario 1, higher heat demand consumption (dark red color coding) is obtained for apartments when compared with other building categories, which reveals to similar conclusions pointed out in other research studies [35], [27]. Furthermore, in the first scenario, houses without thermal insulation in external walls, were found to be the main heat consumers accounting 59.5 GWh/year, followed by houses with 49.4 GWh/year, apartments 25.8 GWh/year, public 10.5 GWh/year, industrial 7.18 GWh/year and 0.29 GWh/year office buildings respectively.

In the second bottom-up scenario 2, the share of heated rooms in houses with and without thermal insulation in external walls was taken into account. As a consequence, the overall heat demand consumed by entirely assessed buildings was estimated to be **50.6** GWh/year, which was quite near the results obtained from top-down mapping. In contrast, when considering the share of heated rooms in the second bottom-up scenario, the heat consumed by houses has changed drastically compared with previous scenario 1. It was found that the apartments are the main heat consumers in the small city assessed accounting 25.8 GWh/year, followed by public buildings with 10.5 GWh/year, industrial 7.18 GWh/year, houses 3.5 GWh/year, houses without thermal insulation 3.2 GWh/year, and office buildings 0.3 GWh/year, respectively. This leads to the conclusion, that when assessing heat demand mapping with a bottom-up approach in underdeveloped area locations, a particular focus should be given to apartment and public buildings, while less attention should be paid to houses that are partially heated. In figure 9, map grids showing higher dark red colors, are indicated by the area location of the apartment and public buildings, respectively. Therefore, the heat demand is also located mostly in area locations with a high share of apartments.

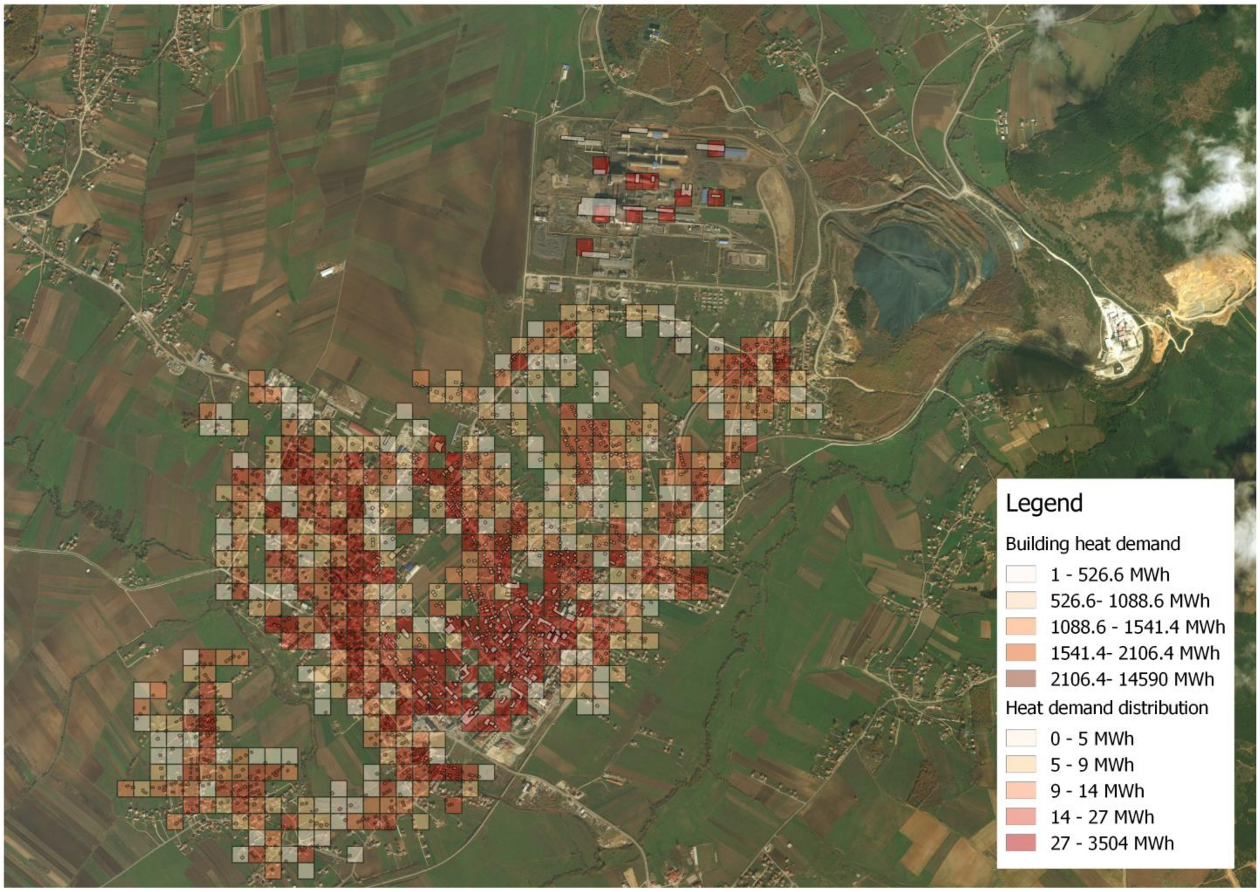

Figure 8. Heat demand distribution in Gllogoc city using bottom-up mapping (Scenario 2).

In addition to that, for such houses, the building height does not have any impact on final heat demand mapping results. For that reason, when assessing another bottom-up mapping for buildings that experience similar physical and behavioral conditions, house heights can be neglected, and the assumption which can be adopted is that all the houses are heated partially up to an average surface. For houses with insulation, such average surface resulted to be 53 m^2, while for the houses without thermal insulation 45 m^2 respectively.

Another assumption that is made in the second scenario, is the neglecting of identified houses, which are heated partially to one, two, three or even more rooms due to the lack of available provided data. On the other hand, since the overall heat demand consumed annually by houses is small compared with the apartment and public buildings such an assumption does not have any significant impact on final bottom-up heat demand distribution maps.

Similar bottom-up mapping methodology can be used for assessing other heat demand maps in other cities with similar physical and behavioral experience of buildings, respectively houses. Since the other municipalities in Kosovo have shown almost the same the share of heating rooms, methodology and assumption presented in this research can be used for assessing the other heat demand maps respectively for analyzing the utilization potential of future district heating in cities.

CONCLUSIONS

The methodology used for the validation of bottom-up heat demand mapping using the results obtained from the top-down approach has been successfully applied for the residential and commercial end-users. The same approach can be used for assessing the heat demand mapping in other small underdeveloped cities, with less meaningfulness to the developed ones. On the other hand, even the other proved bottom-up approaches assessed for cities in Europe so far, can reveal in wrong results outcomes compared with bottom-up assessed mappings for underdeveloped cities area locations.

The methodology assessed for the second bottom-up scenario with partially room heating of houses is strong with respect to weather influence as well as building features when compared with top-down mapping, which does not take such influences into account. Furthermore, it was found that if the buildings are heated to their net areas (scenario 1), the estimated city heat demand can be oversized, which was not the case, if partially heated buildings reflected (in scenario 2), are taken into account. In the first scenario, it was found that overall heat demand was tripled 153 GWh/year compared with the reference scenario 53 GWh/year. In contrast, this difference in results was almost neglected between second and referent scenario 51 GWh/year and 53 GWh/year respectively.

In contrast, the application of this approach requires more detailed input data compared with other models. It demonstrates the fact that future models should consider the end use behavior when modeling heat demand spatially and temporally. It applies adjustable spatial resolution but it's limited to large area application due to limited data and time consumed for processing such data.

The height of houses is neglected in second scenario and it can be applied in other models when assessing future bottom-up heat mapping in under developing countries. Another assumption which is adopted in second scenario is that all the houses are heated partially up to an average surface. Such surface can be taken from building cadaster datasets. For houses with insulation, such average surface resulted to be 53 m^2, while for the houses without thermal insulation 45 m^2 respectively. Furthermore, another assumption that is made in the second scenario, was the unavailability to identify houses, which are heated partially to one, two, three or even more rooms due to the lack of available provided data. However, since the overall heat demand consumed annually by houses is small compared with the apartment and public buildings such an assumption does not have any significant impact on final bottom-up heat demand spatial distribution maps.

Similar bottom-up mapping methodology can be used for assessing other heat demand maps in other cities with similar physical and behavioral experience of buildings, respectively houses. Since the other municipalities in Kosovo have shown almost the same the share of heating rooms, the methodology and assumptions presented in this research can be used for assessing other heat demand maps.

Future work of this paper might be the use of available known methods for assessing the utilization potential of future district heating system.

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