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SimTerm2022 PROCEEDINGS

20th International Conference on Thermal Science and Engineering of Serbia

Niš, Serbia, October 18-21

ENERGY EFFICIENCY ECONOMY ECOLOGY

SimTerm2022

PROCEEDINGS

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Urban Energy Mapping: Best Practices and Perspectives of Implementation and Application in Serbia

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Abstract: Energy management at the urban scale is an important area of study since cities consume a significant amount of world energy and emit considerable CO_2. The environmental, economic, and social aspects of urban spatial planning are all influenced by energy systems. Energy consumption impacts the urban microclimate, comfort, and human health, and the physical, economic, and social aspects of cities affect the urban energy profile. Local governments require decision support tools, which rely on reliable energy data to improve the quality of energy strategies, programs, and plans, which have become increasingly important in recent decades. This paper aims to present urban energy mapping as a powerful tool that combines urban spatial data with energy data to improve the quality and effectiveness of energy planning while facilitating the convergence of energy and spatial planning. In the paper, the data contained in the maps are presented, and the problems related to the availability and usability of energy data and difficulties in processing for the development of energy maps are discussed. The paper presents examples of best practices of cities that have implemented energy maps and explores the prospects for developing and implementing energy maps in urban areas in Serbia. The full utilisation of these maps may empower policymakers to adopt more sustainable and informative policies, which may contribute to affordable and reliable energy for all and simultaneously decrease CO_2 emissions.

Keywords: urban energy mapping, energy demand modelling, energy planning, build environment, GIS.

1. Introduction

Human society is facing two major energy problems. The first is the lack of energy and insecurity in its supply, and the second is environmental pollution and climate change caused mainly by excessive and irrational energy consumption. Buildings are one of Europe's largest sources of energy consumption and environmental pollutants. They account for around 40% of final energy consumption and 60% of electricity consumption in the EU, while they are responsible for 36% of greenhouse gas emissions [1], which mainly stem from construction, usage, renovation and demolition. Today's trend of urbanisation, which reached its historic moment in 2007, since urban dwellers formed the majority of the global population and with forecasts that by 2050 the urban population will get 66% [2], will undoubtedly increase the stated values of energy consumption in buildings and pollution caused by. Therefore, it is rightly considered that energy efficiency in buildings is an area that significantly contributes to solving these two problems: reducing energy consumption and reducing environmental pollution [3].

Because of the rapid growth of cities and the increase of their density, which is a significant contributor to energy efficiency [4], the point of view of the energy efficiency improvements has shifted from the building level to the city level. Moving to the city level, the role of cities in total energy consumption and pollution is even more dominant. In 2014 the Intergovernmental Panel on Climate Change estimated that cities account for "between 67–76% of global energy use" and "between 71% and 76% of CO_2 emissions from global final energy use" [5], certainly playing an important role in affecting long-run emissions trajectories but at the same time making them potentially powerful levers for the energy transition. Towards this transition, quality energy strategies, policies, and plans are needed and rely on quality data from which energy data are crucial. The EU Commission report Supporting digitalisation of the construction sector and SMEs revealed that the construction sector is underdeveloped in terms of overall digitalisation and data applications compared with other industrial sectors [6]. The lack of consistent and reliable building-related data, not only data related to the physical building characteristics and embodied materials but also the data related to the building operation, could prevent adequate benchmarking and progress tracking of performance improvements and energy use and lead to increased risk in achieving the goals set in the strategies. To contribute to several high-profile policy EU initiatives such as European Green Deal and its Renovation Wave and further Building Renovation Passport, Energy Performance Certificates, and Smart Readiness Indicator, the "EU-wide Framework for a Digital Building Logbook (DBL)" has been established [7]. This document defines a digital building logbook as a common repository for relevant building data, focusing on energy efficiency and materials. It facilitates transparency and increased data availability to a broad range of market players, including construction stakeholders (developers, investors, financial institutions, contractors, etc.), property owners, tenants and public administrations. Although introducing the Digital Building Diary is a step in the right direction, much remains to be done before it becomes commonplace in the market. These activities go toward linking DLB with the existing databases and solving the issues related to data management and interoperability. Until then, it remains to develop and expand the application of existing solutions that could also encourage data transparency, increase data availability, and enable synergy, interoperability, data consistency and information exchange.

Over the last decade, the Energy Potential Mapping (EPM) method has evolved rapidly to visualise local energy potential and demand and to support the integration between energy and spatial planning toward more energy-efficient urban or rural areas [8,9,10]. The EU and academic institutions have funded a wide range of energy mapping projects in recent years [11]. The common goal of all these projects was to develop and demonstrate a user-friendly integrated tool that will support local authorities in mapping the potential of locally available energy potential, mapping current and the forecasted demand for energy and enabling them to define and simulate alternative environmentally friendly energy efficiency scenarios and benefit assessments about the current situation. The tool developed within these projects is mainly an open web-based city-level GIS map with integrated energy data provided by the private sector and public bodies. Such a map is called the energy map.

This paper aims to present urban energy mapping as a powerful tool that combines urban spatial data with energy data to improve the quality and effectiveness of energy planning while facilitating the convergence of energy and spatial planning. In the light of this, a wide range of the last decade's realised projects focused on developing energy mapping tools has been presented in the paper, concentrating on the problems in energy data acquisition and processing. Furthermore, the paper presents examples of best practices of cities that have implemented energy maps and explores the prospects for developing and implementing energy maps in urban areas in Serbia. We argue that the full utilisation of these maps may empower policymakers to adopt more sustainable and more informative policies, which may contribute to affordable and reliable energy for all and, at the same time, decrease CO_2 emissions.

2. An overview of projects involving the development of Urban Energy Maps

For a better understanding of development in the field of Urban Energy Maps, the next chapter provides an overview of six major projects funded by the European Commission in the last ten years, which aim to develop techniques and technologies that have applications in this field.

2.1. Project 1: Planheat

The EU-funded Planheat project addresses this issue by developing and validating an integrated and simple-to-use tool that aids local governments in selecting, modelling, and comparing various low-carbon and economically viable heating and cooling options in real-world situations. Planheat's main goal is to develop and demonstrate an integrated tool to assist city governments in selecting, simulating, and comparing alternative low-carbon and economically sustainable heating and cooling scenarios, which will include the integration of alternative supply solutions to balance forecasted demand [12]. Planheat is a QGIS plug-in that analyses, creates, and simulates low-carbon heating and cooling scenarios to help EU governments update and execute sustainable energy plans.

The Planheat integrated tool was designed to assist local governments in 1) identifying the potential of locally available low-carbon energy sources; 2) demand forecasting for heating and cooling; 3) developing and testing alternative environmentally friendly scenarios based on district heating and cooling, as well as highly efficient cogeneration systems, that meet expected demand while leveraging renewable and waste energy sources and demonstrating economic viability; 4) determining the viability of further growth and renovation of district heating and cooling networks by understanding how these unique options relate to current infrastructures and networks and 5) compare the benefits that the new scenarios will offer to the current situation (in terms of energy, economic, and environmental KPIs) [13, 14, 15].

2.2. Project 2: Stratego

The Stratego project's overall objective was to develop low-carbon heating and cooling plans, known as Heat maps, and then measure the impact of their adoption at the national scale for five Eurozone Members, such as the Czech Republic. Croatia, Italy, Romania, and the United Kingdom are participating countries [16]. Because these countries' demographic, climate, resources, and energy supply varied greatly, the primary findings, conclusions, and recommendations offered in this research can provide information on national energy strategy across Europe. Stratego began by developing national energy models, which included hourly profiles. The supply and demand possibilities for heating and cooling were identified using geographic mapping. The potential for district heating and cooling has been calculated using these spatial demand data. Renewable heat sources in Europe have been mapped by assessing available excess heat and estimating available renewable sources. This was utilised to model the energy system on EnergiPLAN, allowing for cost, efficiency, and renewable energy analysis of systems with integrated heating and cooling requirements [17]. Throughout all five countries, a mix of energy efficiency measures, such as heat savings, district heating in urban areas, and heat pumps in rural areas, reduces energy system costs, energy consumption, and carbon dioxide emissions in 2050 when compared to a 'Business-as-usual' estimate. Investing in energy conservation, district heating, and heat pumps can reduce expenses by 15% of the energy system (35 billion per year in 5 countries). If heat map scenarios are implemented in all five countries, energy demand is lowered by over 1000 TVh per year. The total reduction in carbon dioxide emissions, at 275 Mt per year, is greater than all carbon dioxide emissions now released by the Czech Republic, Croatia, and Romania combined [18].

2.3. Project 3: Scotland heat map

According to the Scottish Government, renewable energy sources are expected to meet 11% of Scotland's heat demand by 2020. With this aim, the project Scotland heat map has been designed and piloted as a GIS-based spatial planning tool or 'heat map' to assist the government in identifying and assessing renewable energy prospects; at the outset of the project, renewable energy sources were anticipated to provide roughly 1.4% of Scotland's non-electrical heat demand [19]. The government can analyse the map using a suite of analytical tools, such as a heat opportunity scenario development tool, to view multiple GIS layers containing information on heat demand and potential heat supply; produce a range of detailed information, such as maps and statistics relating to existing demand and supply; and predict the impacts of various development scenarios, highlighting potential opportunities to implement renewable heat technology. Local governments can also use the map to examine the impact of potential renewable energy developments and utilise the data to drive local development planning. The heat map's ability to test different development scenarios is a major feature that sets it apart from prior editions. The study's findings were tested in three municipal governments. After that, the methodology was utilised to build a national heat map for Scotland.

2.4. Project 4: London heat map

The Greater London Authority launched the Decentralised Energy Master Planning (DEMaP) district energy initiative, which operated from 2008 to 2010, to help it accomplish its objective of having 25% of the energy provided by decentralised sources by 2025. It focused on identifying district heating network opportunities through heat mapping and energy master planning, as well as building capacity within local governments to deliver district energy projects and developing planning policies that encourage and, where appropriate, require district energy in new developments. The London Heat Map, which shows potential heat supply, demand, and network prospects for district energy around the city, was the program's principal product. The London Heat Map is an interactive GIS application that allows users to find decentralised energy project prospects in the city. The Heat Map provides spatial intelligence on factors such as the location of major energy consumers, local and city-wide fuel consumption and CO_2 emissions, energy supply plants, community heating networks, and heat density that are relevant to the identification and development of district energy opportunities. Anyone interested in district energy can use it because it is open to the public [20]. Local governments can use the map to construct detailed Energy Master Plans that will inform district energy policies in their Local Development Frameworks and climate change initiatives. Developers can use the map to track compliance with the London

Plan's district energy requirements. London is already constructing several district heating projects based on potential discovered by the London Heat Map, such as the Lee Valley Heat Network, which intends to give over 5,000 houses essential heating and hot water by capturing waste heat produced from nearby EcoPark [21]. On a city level, London's Decentralized Energy for London program has persisted, aiding the commercialization of major decentralised energy projects, notably district heating schemes powered by CHP and waste heat.

2.5. Project 5: POP Groningen

POP Groningen, also known as MAKING-CITY, is a large-scale demonstration project aimed at developing innovative integrated solutions to address the transformation of urban energy systems to low-carbon cities, using the favourable energy district (PED) concept at the heart of the urban energy transition path. The project was heavily focused on obtaining evidence of the PED concept's actual potential as the foundation of a high-efficiency and long-term path to go beyond current urban transformation roadmaps [22]. This project focused on procedures and methodologies to assist cities in long-term urban planning for an adequate energy transition, opening the path for planning, implementation, and upscaling. This procedure was approached through a three-layer planning process: long-term planning (2050) will be the high-level approach, medium-term planning (2030) will be the medium-term approach, and short-term (action plan) with a time horizon of around five years will be the short-term strategy. Groningen and Oulu implemented extensive PED demonstrations, employing various technical approaches, to lay the groundwork for a long-term energy transformation strategy for the entire city.

2.6. Project 6: ESTMAP3

The ESTMAP project began in January 2015 and concluded in December 2016. The funding comes from the European Commission's Horizon 2020 initiative (2015-2016). The main task of the ESTMAP project is to compile existing data and use it to optimise energy system planning. One of the project's objectives is to contribute to the strengthening of the foundation for long-term planning, as well as the optimisation of our future energy system and the early identification of possible bottlenecks. System modelers, engineers and geologists joined forces the definition the format and the content of a database of both above-surface and subsurface storage sites (existing, planned and potential) to ensure that the new set of data will fit the needs for more robust modeling, planning, designing, etc. on a coherent basis and comparable between the Member States and other European neighbouring countries as appropriate. One of the project's key deliverables is a geographical database comprising information about developed and prospective future subsurface and above-ground storage reservoirs and current storage facilities linked to these reservoirs **[23]**. Geological characteristics, technical properties, recent development, feasibility evaluation for various storage options (e.g. natural gas, compressed air, heat, pumped hydro, etc.) and overlaps with alternative potential for CO_2 storage are all used to describe and parameterise reservoirs and facilities. The database is used to estimate future storage facilities and demonstrate energy system modeling. The database is visualised using GIS maps and is linked to the results of energy system modeling and analysis **[23]**. The system analysis' principal goal is to connect the data collected in the database on storage sites and their capacities to the larger energy system. This includes tying together transmission, demand, and supply data. The system analysis' main goal is to build the foundation for long-term strategic planning and optimisation of our future energy system and identify potential constraints early on.

The project's implementation was funded by investments from EU funds totaling 1,5 milion euros per project. The projects were all completed between 2012 and 2019 and had an average duration of five years. These projects' implementation involved extensive research into energy use in the relevant areas and the viability of deploying renewable energy sources there. Deliverables from these initiatives include 2D and 3D maps of the areas under consideration that include information on building types and energy use. The literature review concludes that significant funds have been invested in developing technologies enabling the development and maintenance of urban energy maps. The next chapter will provide an overview of examples and experiences of energy maps currently in use.

3. Examples of good Urban energy mapping practices

This chapter provides an overview of four Urban Energy Maps that have been developed and are currently being implemented worldwide.

3.1. London Heat map

In October 2010, the Decentralized Energy Master Planning Program (DEMaP) was finished, and the London Heat map was created [24]. The map covers the entirety of Greater London and offers incredibly detailed information for locating prospects for decentralised energy. It contains information like the heat demand figures for each building, the locations of the energy supply facilities, the areas of the district heating systems, and a spatial heat demand density map.

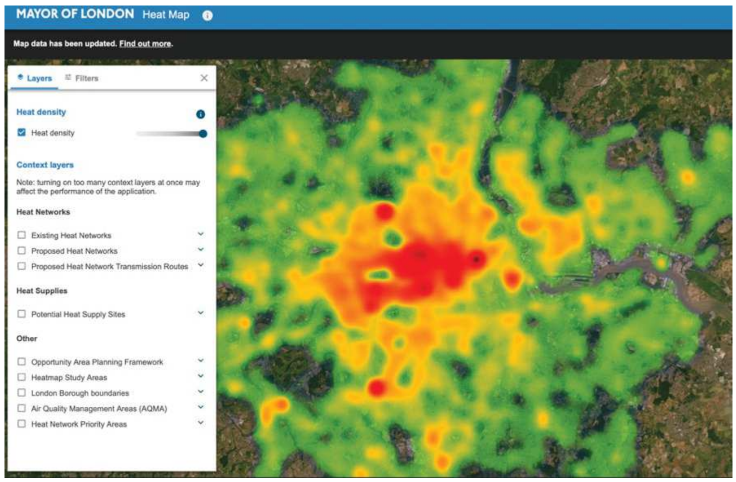

Figure 1. London Heat Map [24]

London Heat Map can display data in layers such as existing heat networks, proposed heat networks, transmission routes and potential heat supply sites (Figure 1). An easy-to-use graphical tool for designing heat networks is included with the map.

3.2. NYC Energy & Water Performance Map

The Marron Institute of Urban Management at New York University and the NYU Urban Intelligence Lab created the NYC Energy & Water Performance Map in collaboration with the Mayor's Office of Sustainability. To better understand the energy and water efficiency of more than 20,000 of the largest buildings spread across New York's five boroughs, Map offers interactive data analysis and query platform. The research team at the NYU Urban Intelligence Lab and CUSP alumni developed this visualisation tool [25].

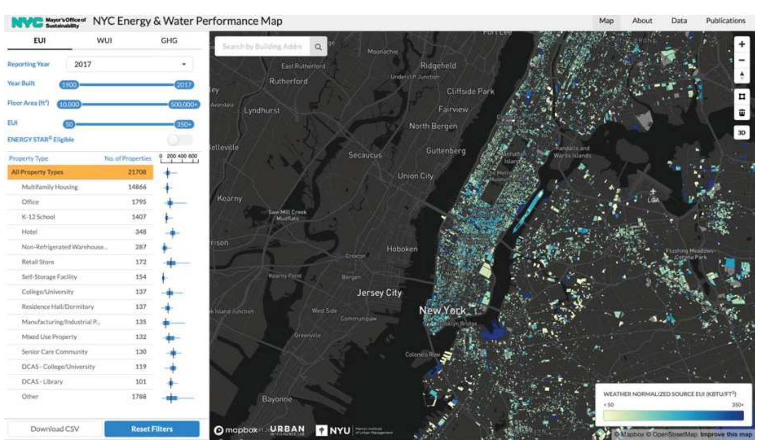

Figure 2. NYC Energy & Water Performance Map [25]

Building statistics such as the year of construction, area, number of floors, number of rooms, etc., distribution comparison, time series comparison, building type breakdown, and energy type breakdown are among the data displayed on this map, as shown in Figure 2.

3.3. Energy And Climate Atlas Helsinki

The Energy and Climate Atlas, displayed using a city model, is a visual and educational tool for the City and residential firms' decision-making, as well as for other players in the real estate and construction industries, like solar panel suppliers. It unifies different types of data material onto a single platform, making it accessible to all users and compatible with all smart devices.

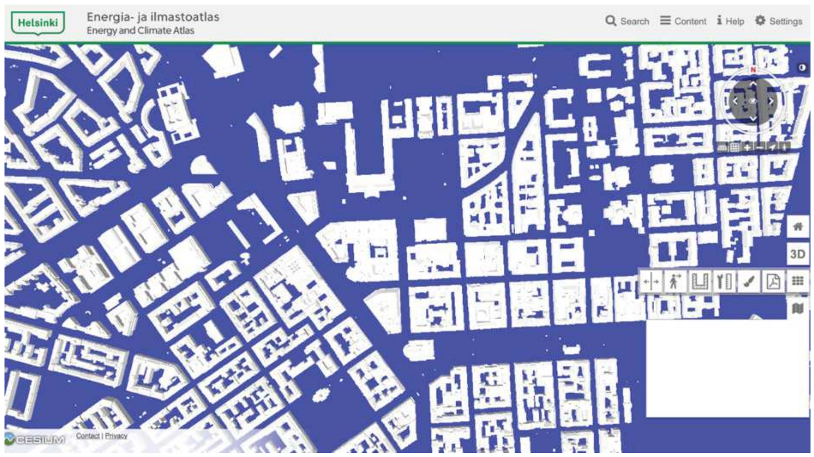

Figure 3. Energy And Climate Atlas Helsinki [26]

A building's details can be found on the Atlas by searching for its address or by going to it in the 3D model. Anyone can utilise the openly available data in the Energy and Climate Atlas [26]. This map displays basic building information, energy, and buildings information and consumption statistics.

3.4. Amsterdam Energy Atlas

Amsterdam's energy atlas gathered data on energy use at the building level. The objective is to give specific stakeholders a dynamic tool to assess various scenarios of using renewable energy, including the implementation costs and the financial and environmental benefits (reduction of CO_2 emissions).

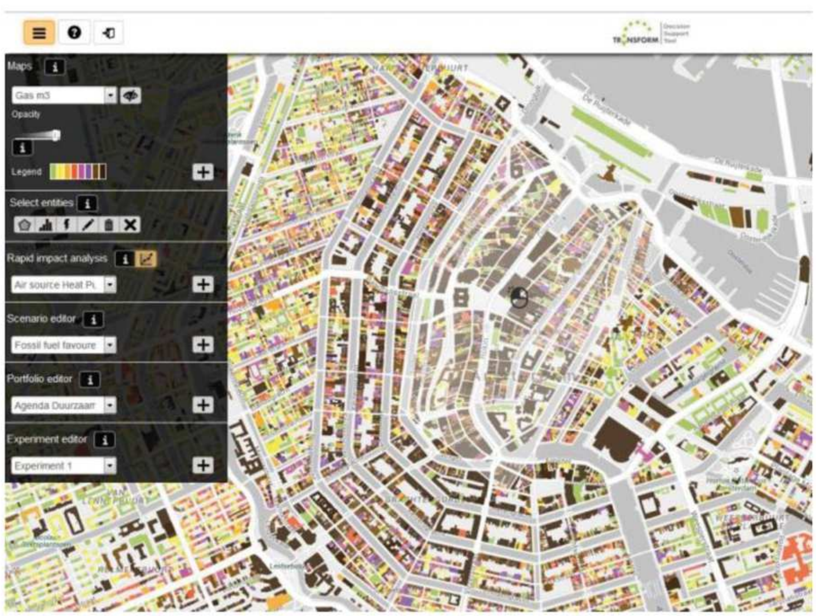

Figure 4. Amsterdam Energy Atlas [27]

To determine the results of each scenario, this web-based tool integrates data collection on energy use, modeling to incorporate knowledge about expected behaviour, and dynamic tools to set the scenario inputs [27].

For large cities that also consume a lot of energy, energy maps are being created. They are intended for use by the general public as well as local government to aid in decision-making in countries with high energy consumption. The following chapters will provide a brief overview of the energy situation in Serbia and the need to develop and implement an energy map, as well as an overview of possible data sources that would help build a map and be integrated into the map.

4. Energy Mapping - Serbian Perspectives

4.1 Serbia Energy Information

In the Republic of Serbia (RS), energy consumption in buildings accounts for 48% of total energy consumption in the RS. As much as 70% of that energy is spent on residential buildings, while the remaining 30% goes to public and commercial buildings. Most of the 70-80% of the energy consumed by residential buildings goes to the energy needed for space and water heating. Of all types of energy and energy sources, the consumption of electricity is the most represented in residential buildings, as much as 44%, and due to the extensive use of wood as a heat source, the share of renewable energy sources is significant at 23%. Compared to the average in Europe, buildings in RS, especially in terms of energy for space heating and water heating, are much larger consumers. The average consumption of thermal energy in residential buildings in RS is 1.6 higher than the European average, 2.3 times higher than in environmentally developed European countries, and over 2.5 more elevated than the requirements set by the state regulation regarding the new buildings [28].

On the other hand, the total technically usable potential of renewable energy sources in Serbia is estimated at 5.65 Mtoe per year, which makes up one-third of the total planned energy at the annual level of 15,169 Mtoe. Still, only a third (34.83%) of the potential renewable energy sources are used. Biomass appears to be the most significant part (61%) of it, followed by hydro (29.7%), solar (4.25%), geothermal (3.19%) and wind energy (1.82%), [3].

By electing the Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030, RS has defined the direction of the national energy policy to maintain the current level of energy consumption in buildings by 2030. This will be achieved by compensating for the energy need in the buildings that have yet to be built by performing energy renovation of many old buildings and reducing their consumption by up to 70 %, mainly in energy demand for heating [29]. According to a draft of revised Nationally Determined Contributions, published in 2020, Serbia plans to reduce greenhouse gas emissions by 33.3% by 2030 compared to 1990 levels, which is still far behind the EU targets, which is the least 55% by 2030. Bearing in mind that in the coming period, the obligations of the Energy Community, of which Serbia is a member, are expected to be harmonised with the obligations of EU member states, which raises the target values to a higher level, Serbia should establish a mechanism to monitor the implementation of activities to precisely identified progress towards each target: reducing energy demand and greenhouse gas emissions.

The development of energy maps that would be interactive and publicly announced platforms is one of the solutions. Thoughts in our country in the direction of creating such maps already exist. The Ministry of Energy and Mining announced at a round table in Bucharest on energy security and the conflict in Ukraine that Serbia's priority is to create a regional energy map that should help maintain and improve stability and security in the energy sector. It is not specified what these maps would look like and what data and countries they would include. However, there is no doubt that Serbia will move towards establishing mechanisms that encourage data transparency and increase data availability to a wide range of market players, which will be used for benchmarking and progress tracking of achieving strategic goals.

The next chapter provides an overview of potential data sources that would be used in developing and establishing such an energy map for Serbia. Two types of data sources were analysed. One that would support determining the energy demand of buildings, and the other kind of sources were publicly available data on renewable energy sources in Serbia.

4.2 Potential Data Sources for Energy Mapping

Potential sources of data that could facilitate obtaining data on the energy consumers' fond and the energy demand of each building within would primarily be: the Central Register of Energy Passports, under the Ministry of Construction, Transport and Infrastructure responsibility; Electric Power Industry of Serbia, Srbijagas, Energy Management Information System (EMIS), Republic Geodetic Authority, Statistical Office of the Republic of Serbia. An overview of the data types that can be obtained from these sources and possible applications in developing energy maps is given in Table 1. The information regarding the data applicability is taken from the analysis conducted to elect the Long-term strategy to encourage investment in the renovation of the national building fund of the Republic of Serbia until 2050 [30].

Table 1 Supporting data sources for energy mapping in Serbia.

Institution/Source	Availability	Data Type and Applicability
Central Register of Energy Passports	Public Data	The database provides data on the building's size, structure, characteristics and typology, the calculated value for the amount of final energy on an annual basis for a building, as well as the energy class of the building. In 2018, the obligation to enter data into the database was defined. Disadvantages: The data of energy passports entered into the database are inaccurate in structure in individual elements.
Electric Power Industry of Serbia	User data on request	EPS data provide insight into the number of facilities that use energy, and it is possible to provide data on annual energy consumption per consumer.
Srbijagas	User data on request	It is possible to obtain data on each consumer on an annual basis.
Energy Management Information System	User data on request	The data embedded into this database are the type of facility, name of the facility, calculated amount of energy consumed, name of the supplier, year, month, and the energy source. The database has an option to export data, which can facilitate data processing. Disadvantage: Databases contain valuable data for buildings but lack data for many buildings.
Republic Geodetic Authority	Public Data	The database contained data necessary for generating 2D or 3D models of the buildings within the region for which the map is made. Disadvantages: insufficient data accuracy. RGZ does not have detailed data on unregistered buildings; the total size of buildings is often not relevant. The database does not contain over 4.3 million new or significantly changed facilities whose changes have occurred since 2016 and over 1.2 million buildings removed from the field. No entry has been made in the real estate cadastre database.
Statistical Office of the Republic of Serbia	Public Data	This database can be used to study the structure of the housing stock in various aspects (size, age, structure, distribution…) and based on the data from other databases to conduct further analysis.

When it comes to data sources that could be used to determine the potential spatial capacities of renewable energy sources in Serbia, the situation is much more favourable given the numerous projects that have been implemented globally and resulted in energy maps covering Serbia. In 2017, the World Bank Group, funded by Energy Sector Management Assistance Program (ESMAP) and in collaboration with the company Solargis, launched the Global Wind Atlas and Global Solar Atlas as free, web-based maps to help policymakers, planners, and investors identify high-wind areas for wind power generation virtually anywhere in the world, as well as to provide them quick and easy access to solar resource and photovoltaic power potential data globally. Maps in high resolution and datasets are available for Serbia, and they are free to download, share, adapt, and use in GIS tools or public dissemination. Besides this, numerous other projects have resulted in open web-based datasets or maps integrating various information on the renewable energy potential in the EU or worldwide containing the data for Serbia. Such datasets include geothermal power plants, wind power capacity, air pressure levels, photovoltaic power potential, and available solar heating and cooling systems. A list of these sources, along with the description, in brief, time reference, availability, resource type and metadata URLs, is presented in Table 2. It could be a potential data source for developing energy maps in Serbia. All data shown in Table 2 are taken from the publicly announced EnerMaps project results.

Table 2. Available datasets and maps on renewable energy sources in Serbia

Title (with Hyperlink)	Description (in brief)	Level	Time references (time data refers)	Availability	Resource type
JRC: Geothermal Power Plant Dataset	Dataset of worldwide geothermal power plants, including technical details (e.g. nameplate and running capacity, turbine type).	Worldwide	Region-specific data sources range from 2010 to 2018	Available on the web	Dataset
EMHIRES: Wind power generation	High resolution renewable energy generation time series data of wind power capacity factors at NUTS 2 level.	EU27 + UK + Iceland, Balkans	1986-2015	Available on the web	Dataset
Copernicus: hourly data on pressure levels	Data containing pressure levels (a subset of the ERA5 reanalysis dataset).	Worldwide	1979-2021	Available on the web (login required)	Dataset
Photovoltaic power potential	Photovoltaic power potential for Europe.	Worldwide	1999-2018	Available on the web	Dataset
IEA SHC Large Solar Heating and Cooling Sys.	A database with detailed descriptions of large solar heating and cooling systems from all over the world.	Worldwide	1985-2014	Available on the web	Dataset
ENTRANZE: Average size of dwelling in residential sector	Building stock data, including floor area of residential and non-residential buildings, heating/AC system data, and energy use by sector.	EU27 + UK, Serbia	2008	Available on the web	Dataset

Based on the analysis of possible data sources that would support the development of an energy map for Serbia, it can be concluded that in terms of information related to renewable sources, numerous studies have been conducted that include Serbia's potential. All available datasets and maps can be easily accessed; they are free to download, share, adapt, use or public dissemination. On the other hand, even if there are numerous data on building stock in Serbia and many sources of energy consumption, they are not well systematised and structured; further, the data are not reliable and up to date and do not cover all buildings in Serbia.

5. Conclusion

In this paper, energy mapping has been presented as a powerful tool to integrate spatial and energy data at the city level and further utilise them. Research on several implemented projects to map energy data has been conducted to confirm this. In addition to the projects, the already developed, launched and currently using city energy maps have been researched. The research showed that many projects encouraging the energy mapping method had been funded in the last ten years. The number of developed energy maps currently in use is significant. The local renewable energy potential and quantified demand at the building level are mostly visualised in 2D or 3D GIS maps. The final intention of the maps is to encourage data transparency, increase data availability to a wide range of market players, and enable the local authority to create more effective and efficient strategic policies and better track the progress of achieving the set goals.

Furthermore, the paper explored the prospects for the development and implementation of energy maps in urban areas in Serbia. Such an idea already exists in the Government. There is currently a large amount of available data on the potential of renewable energy sources in Serbia. In contrast, data on individual energy consumption in buildings and their negative environmental impact are limited, and it is necessary to make some efforts to obtain reliable data.

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