Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. X, 2021
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

SOLAR CADASTRE IN TIMISOARA, ROMANIA

Anca Maria MOSCOVICI, Clara Beatrice VÎLCEANU, Sorin HERBAN, Carmen GRECEA

Politehnica University of Timisoara, Civil Engineering Faculty, Department of Overland Communication Ways, Foundations and Cadastral Survey, 2 Traian Lalescu Street, Timisoara, Romania

Corresponding author email: anca.moscovici@upt.ro

Abstract

The topic of the paper refers to solar cadastre regarded from the point of view of choosing the optimal areas for placing photovoltaic panels and the importance for implementing sources energy. In the scientific literature, solar cadastre is also known as roofs cadastre or potential solar cadastre. It is based on the digital terrain model and climate information available for studied areas. Analysis of solar energy and full potential of solar cadastre can be used in various fields as civil engineering or urban planning, also in the projects of research and the investment of energy sources. An important aspect of the presented study case is the decrease of the use of agricultural lands for photovoltaic parks. One way to generate renewable energy in our existing urban environment is to use the solar energy. A method for analysing the potential of existing built environment for obtaining energy sources is by creating solar maps. A solar map or a solar cadastre is a GIS that provides data about yearly solar radiation on the building's surfaces (roof and/ or facade). The current solar maps have different levels of advancement.

Key words: *agricultural lands, Digital Terrain Model, geoportal, renewable energy, solar cadastre.*

INTRODUCTION

Given that pollution is increasingly affecting both the environment and the population, the idea of implementing projects targeting alternative energies that contribute to ensuring a healthy and safer environment for all the factors involved is of great importance. This is also because it represents an international concern, to discover new methods of green energy production.

In highly populated analysed territories, the expansion of construction zones and the pressure imposed on the slopes by housing and transport infrastructure led to the appearance and reactivation of mass movement processes that affect both population and the environment (Sestras, 2019).

In contrast with the past, the energy issue has become a crucial component of ecologically and economically sustainable urban development. The conventional energy sources such as oil, gas and coal are tending to decrease, whereas renewable energy sources such as solar energy, wind power, hydropower, biofuel, biomass and geothermal energy are making a great contribution into producing electric energy, domestic hot water, heating and motor fuels (Chuprikova, 2015).

The potential of solar energy is very high. Every half hour, the Earth receives from the Sun an amount of energy equivalent to the energy consumption of mankind for a whole year. That is why solar energy represents the energy alternative of the future.

Solar energy can be used for technologies such as: solar heating, photovoltaic panels, solar thermal energy, solar architecture and artificial photosynthesis. This is an important source of renewable energy and its technologies are generally characterized either by active solar techniques or by passive solar techniques based on how they capture and distribute energy in solar energy.

Active solar techniques include the use of photovoltaic systems, concentrated solar energy and solar energy to heat water for energy recovery.

Passive solar techniques include orienting a building to the Sun, selecting favourable materials for heat or light scattering, and designing spaces naturally ventilated. Renewable energy sources offer a viable alternative with low or no risks that are

practically inexhaustible from the point of view of resources.
The most important solution to protect the environment is the regeneration of the energy source: solar, biomass, wind, water, geothermal energy, waves and tidal power. So, one of the ways to reduce CO_2 concentration in the air is to use renewable energy sources, including energy from the Sun.

MATERIALS AND METHODS

The solar cadastre is also called the roofs' cadastre or solar potential cadastre. This type of cadastre consists in a geoportal that allows defining the potential of solar energy for specific locations. It is based on the Digital Terrain Model and climate information available for the studied areas. This type of geoportal is mainly developed as an initiative of the local governments. (Popescu G. et al., 2020)
The data characterizing radiation modelling and energy production on building roofs and integrated vertical facades uses light detection data and measurement data (LiDAR) together with 2D and 3D cadastral data lands is recorded in a webGIS containing geometric details, structures, current situation and property information.
LIDAR (Light Detection and Ranging) technology is an active remote sensing technique with used in order to obtain high accuracy data regarding land topography, vegetation, buildings etc. LIDAR technology represents an effective method of detecting buildings: the larger ones are easy to be identified in contrast to smaller buildings which are harder to identify.
Another method is to combine aerial photographs and existing contours of buildings from the 2D cadastre and even terrestrial laser scanning. In the scientific literature and current practices, facades modelling for solar analysis has received less attention compared to roofs, because it requires much more complex tools based on 3D data. However, these elements from the built environment can be used for assembly solar panels.
An inconvenience for assembly solar panels on facades is the urban vegetation and thus the maximum efficiency of these panels would be obtained only in winter.
The integration of photovoltaic panels (PV panels) on the roofs is still critical from the point of view of the landscape. No impacts on biodiversity or water can be identified. A positive impact on soil preservation is identified on the use of roofs to install the PV panels instead of the occupation of agricultural land.
A very important tool for solar cadastre is represented by 3D cadastre, namely by introducing the third dimension, different situations regarding the built areas can be better illustrated. Also, the introduction of the third dimension and the management of information in a GIS environment for both 3D cadastre and solar cadastre contributes to the clarification of energy consumption and for the development of photovoltaic panel infrastructure (Moscovici et al., 2019)
Solar energy analysis and solar potential maps can be used in various fields such as civil engineering or space planning, as well as in renewable energy research and investment projects.
Cities, which are home to more than half of the Earth's population, consume most of the world's energy. One way to generate renewable energy in our existing urban environment is to use solar energy. A method of analysing the potential of the existing built environment for obtaining renewable energy is through solar maps.
A solar map or solar cadastre represents a webGIS that provides data on annual solar irradiation on building surfaces (roof or facade), mostly accompanied by data regarding the production of solar thermal or photovoltaic systems (Klauser, 2013) (Figure 1).
Current solar maps have different levels of advancement. Sometimes, cities solar maps are part of larger programs implemented in order to obtain data needed for higher renewable energy production. They provide users with direct information on solar system suppliers and installers.

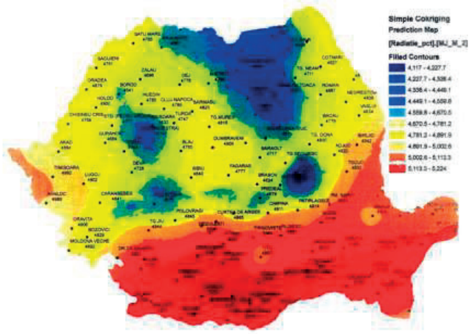

Figure 1. Zoning Romania's territory according to main sunny area

RESULTS AND DISCUSSIONS

Solar energy will play a significant role in order to meet a considerable percentage of its demand for electricity from domestic renewable sources, which means the need for a substantial increase in photovoltaic capacity.

Unfortunatley, at the present moment, there is a lack of knowledge regarding solar cadastre in the urban and rural areas of Romania, in particular in for Timișoara city and the county of Timiș. A solar cadastre on the roof was studied only in urban agglomerations (Figure 2).

At present, the solar cadastre in Timișoara represents a challenge and that is why we considered that it is worth paying attention to this subject.

For the current study, the buildings delimited by the following streets: Plautius Andronescu Street, Oltul Street, Victor Babeș Boulevard and Traian Lalescu Street have been chosen (Figure 3). The studied area includes buildings belonging to the Civil Engineering Faculty and also residential buildings.

After the area for the pilot study was clearly determined, identification of existing roofs on the orthophotoplan followed. For this stage we consulted Eterra's national real estate registration system and we vectorized the buildings that were not registered in the cadastral records (geoportal Eterra, 2020). We also used Google Maps for geospatial data; although it is an online application it could provide useful information for the study (Figure 3).

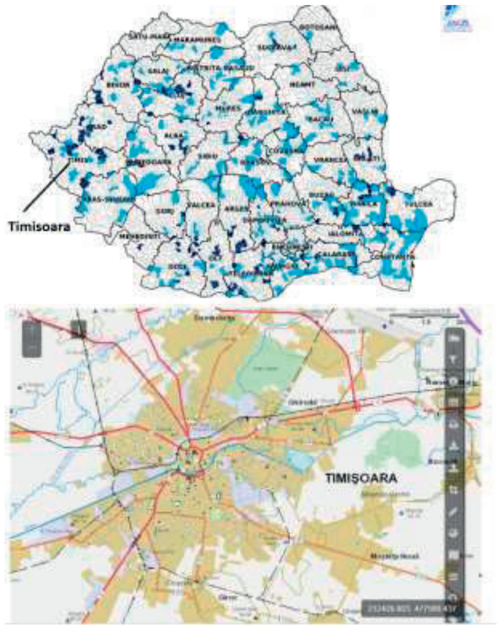

Figure 2. The location of the area studied on the map of Romania (geoportal ANCPI)

Solar technology ensures transforming energy from the sun through sun panels and converting it into heat or, by means of systems photovoltaic (PV) in the energy supply.

When it comes to solar energy, not all roofs have a uniform structure, which is an impediment in the surveyors' activity to identify them only on orthophotoplans.

Each roof, building or structure has its own solar capabilities, depending on the position of the Sun, the season and the nature of its surface. In addition, the shading of elements of the studied area and adjacent objects influence the capacity of solar energy.

The adoption of solar technologies is growing quickly, also thanks to large and urban-scale solar cadastre maps, often available on-line. Identifying suitable surfaces in urban or rural areas plays an important role both for the private investor and the public local community because PV systems need to be properly located and oriented in the environment to meet the required specifications (Agugiaro et al., 2012).

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. X, 2021
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

Figure 3. The area under study

The next step consists in identifying the roof types on orthophotoplanes using all sources Ettera Orthophotoplan, Google Maps. The characteristics of an identified roof included the 2D contour obtained from the orthophotoplan and 3D parameters extracted from the digital terrain model.

Five types of roofs were considered: terrace type roof, pent roof, ridged roof, whole-hip roof and gable roof (Figure 4).

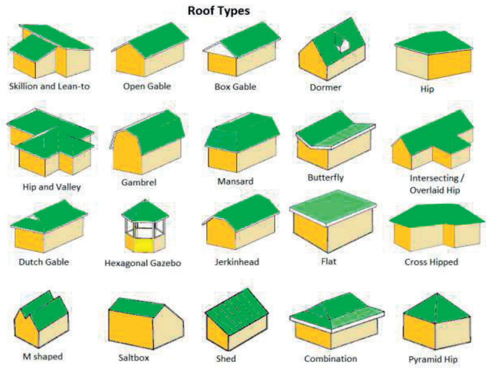

Figure 4. Types of roofs

We performed the vectorization of the roof footprint and at the same time we identified the roof type, taking into account the elements that are of interest for solar cadastre. These are the ridge of the roof, the slope of the roof, the edge of the roof, the skylight, the eaves and the rain shadow as it can be seen in Figure 3.
The parameters of the photovoltaic modules derived from the building characteristics were then combined with data on solar radiation to assess the solar photovoltaic potential. Based on images obtained from Google Earth and the digital terrain model, the buildings were extracted using the object-oriented classification method. The chosen method proposes that after vectoring on layers all identifiable elements, the exclusion of objects including parks and vegetation using shape and texture characteristics. By eliminating them, the active layer of the buildings is subjected to the digital model of the terrain.
Figure 5 illustrates the studied area with the building's geometry and the constructive elements of the roof's identification. A legend was realized in order to explain each type of hatch used.

Figure 5. The studied area for roofs identification

This application can be used to create a database in which the surfaces useful for the location of photovoltaic panels are entered, the calculation of their inclination angles and the distance at which they can be mounted.

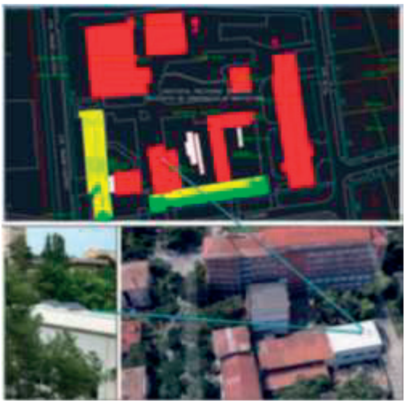

Figure 6. Photovoltaic panels identified on map

The main challenge is to achieve maximum efficiency, but to maintain the necessary accuracy of all points of interest for a solar cadastre. We consider the possibility of using UAV photogrammetry and laser scanning for solar cadastre and whether these methods are practical for such a study. The accuracy of the detailed survey based on UAV technologies was verified on hundreds of points for this study, mainly on the corners of buildings and on the cornices of roofs. Another discussion implies precision work for the location on the rooftop required for mounting solar panels taken into consideration all the 3 dimensions and the angle between the panel and the horizontal line.

On the metal construction assembly room, photovoltaic panels are already installed as we have indicated (Figure 6).

As regards the legislation in force on the studied issue, the Romanian institutions must meet the following directives and laws:

- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, (Figure 7)
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast),
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of energy from renewable sources use,
- Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the building's energy performance.

Figure 7. Classes of Energy efficiency

At national level, the main legislative documents, in force in Romania, regarding the promotion of the use of renewable energy sources and the energy performance of buildings are:

- Law no. 159/2013 on amending and supplementing Law no. 372/2005 on the building's energy performance;
- Law no. 220/2008 for establishing the system for promoting the production of energy from renewable energy sources, with subsequent amendments and completions.

CONCLUSIONS

The solar cadastre is a topic of significant interest to the community, authorities and property owners.

Architectural harmony represents an important point in the successful integration of the components of the installation that use solar energy in a building. However, so far, the most common solution has been to install solar collectors on support structures.

On terrace-type roofs or on terraces across Europe, solar panel builders, architects and their customers are working to integrate solar collectors into the environment. Effective solutions for the integration of solar panels in roofs are well known, especially in Northern Europe, in Romania this issue being only in an incipient phase.

In general, the task of identifying suitable surfaces for the installation of photovoltaic panels is not trivial. Therefore, in order to produce estimations of solar potential, several parameters must be taken into account, for example: azimuth, elevation, shadow, sunlight intensity and climate impact. Therefore, solar simulations based on the digital terrain model and the digital model of high-resolution surfaces must be performed, these data will be taken into account in the future to develop this theme.

By using photovoltaic (PV) panels, the received solar energy is transformed into electricity. Identifying suitable areas for the installation of photovoltaic parks in urban or rural areas plays an important role for both the private investor and the local public community, as photovoltaic systems must be properly located and oriented in the environment to meet the required specifications (insulation time, surface orientation).

The solar cadastre can be used to assess the potential of a city or region to produce solar energy. The solar cadastre allows us, in fact, to evaluate the effective energy efficiency of buildings and land in terms of photovoltaic potential and its adequacy to accommodate this type of photovoltaic system.

An increasingly studied problem is represented by the use of good land (from the agricultural point of view) for the construction of photovoltaic parks given that productive agricultural land should be protected even if the purpose of its modification is to produce renewable energy. The solar cadastre in urban areas with the PV panels on rooftops highly supports agricultural land protection policies and complies with the energy production policies.

REFERENCES

Agugiaro, Giorgio & Nex, Francesco & Remondino, Fabio & de filippi, Riccardo & Droghetti, Shamar & Furlanello, Cesare. (2012). Solar radiation estimation on building roofs and web-based solar cadaster. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences. I-2. 10.5194/isprsannals-I-2-177-2012.

Chuprikova, E., Costa, A., Innerebner, M., Monsorno, R., Wagner, J. E., Moser, D., & Zebish, M. (2015). *An Assessment of the Solar Potential of Roofs within a Web-based Solar Cadastre*. GI_Forum,, 2015, 225-228.

Desthieux, G., (2019). Developing the Geneva Solar Cadaster: A decision support tool for sustainable energy management in urban areas, Research OUTREACH (106)

Klauser, D., & Remund, J. (2013) *Grid planning for high penetration photovoltaics based on a solar cadastre*, Research Gate.

Moscovici, A. M., Banescu, O. A., & Vaduva, R. (2017). Integrating brownfield sites into city redevelopment strategies. International Multidisciplinary Scientific GeoConference: SGEM, 17, 675-682.

Moscovici, A. M., Păunescu, V., Sălăgean, T., Călin, M., Iliescu, A., Suba, E., ... & Manea, R. (2019). 3D Cadastre: A Smart Approach for Road Infrastructure. AgroLife Scientific Journal, 8(1), 192-197.

Popescu, G., Popescu, C. A., Herbei, M. V., Horablaga, A., & Smuleac, A. (2020) 3d Modeling Of Waste Dumps In Order To Ecology Of Mining Areas. AgroLife Scientific Journal, 9(2), 240-249.

Sestraș P, Bilașco Ș, Roșca S, Naș S, Bondrea MV, Gâlgău R, Vereș I, Sălăgean T, Spalevic V, Cîmpeanu SM (2019). Landslides Susceptibility Assessment Based on GIS Statistical Bivariate Analysis in the Hills Surrounding a Metropolitan Area, Sustainability ISSN: 2071-1050, 1-23, 11(5).

Solcan, P., Sălăgean, T., Șuba, E. E., & Ilea, M. (2019). Researches Regarding the Use of GIS Technologies in Modelling and Spatial Analysis of the Varatec Mining Complex, Maramures County. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, 8, 148-151.

http://geoportal.ancpi.ro/geoportal/imobile/Harta.html

https://op.europa.eu/en/publication-detail/-/publication/54b16aac-2982-11e7-ab65-01aa75ed71a1/language-en/format-PDF/source-67528950

https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en