SolarEnergo – New way to bring renewable energy closer

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Abstract— **In recent years people are increasingly opting for energy self-sufficiency of their residential and commercial buildings. The application of solar energy is one of the most attractive options, since the installation of photo-voltaic systems is fairly easily. The question is often on which parts of the roof is best to put such systems to achieve the most optimal use. New public e-services SolarEnergo is constructed and visually shows how much the roof is suitable for the installation of photo-voltaic systems and gives detailed calculation on the amount of solar energy throughout the year. The calculation takes into account also shading from other buildings, terrain within a radius of 15 km and high vegetation. The project has successfully acquired funds from the Ministry of Education, Science and Education in Slovenia and European Regional Development Fund for innovative IT solutions. For the development Municipality Beltinci is cooperating with the Faculty of Electrical Engineering and Computer Science, where the experts have the necessary knowledge and experience to develop advanced solutions in the field of geographic information systems (GIS). The accuracy of topology information and information about high vegetation is achieved using data from airborne laser scan technology LiDAR (Light Detection and Ranging), which scans terrain and buildings at a resolution of 20 points/m^2. For the development of the web and mobile e-service open source platforms in the field of GIS are used. Thus, we have shown that even with less expensive technology, reliable and advanced applications can be developed. The result is a new web and mobile e-service SolarEnergo that allows citizens to easily select the object also with the help of smart Android phones and GPS positioning. With this, Municipality Beltinci offers a new e-service, which can provide, directly in the field or from the office, all the necessary information to decide on the use of solar energy. In the next step SolarEnergo can be easily upgraded and extended to other municipalities or also to whole countries.**

I. INTRODUCTION

Solar energy is today an indispensable source of renewable energy, converted into electricity by photo-voltaic systems (PV). Therefore, the use of such systems for different purposes is increasing. In most cases, the systems are installed on the roofs of buildings. In doing so, the problem is to provide an optimal installation of PV systems concerning the received solar radiation on the surface of the roof, since it is necessary to take into account the various factors which affect the strength of the received solar radiation. Such measurements are carried out by experts in this field, but they are very expensive and much less accurate. Thus, in the last decade solutions were developed, which allow the user more precise and automated calculation of the solar potential (daily solar radiation) over the surface of the selected roof. These solutions give the users a detailed overview of the received solar potential on the roof surface throughout the year as well as an overview of the cost of installation of PV systems from different manufacturers.

Through e-services a municipality may give to its citizens, tourists and investors a variety of information and services. In this way, municipalities can adapt to the trend of increasing communication via modern information technologies. We can find many good practices in the use of e-services for citizens in some EU countries. Even the Slovenian e-government portal "E-Uprava" is a fine example of a national level e-service for citizens.

In the current e-service calculations of the solar potential, which are based on an analysis of several years of meteorological data of solar radiation and shading simulation of classified LiDAR data (Light Detection and Ranging) are used. They also take into account the roof's topographical features (orientation and slope). The results of the calculations are stored on the server part of the geographic information system (GIS), and are accessed by the application on the client side.

LiDAR technology consists of a laser transmitter that emits laser pulses to determine the position of objects on the surface [1]. The result of LiDAR air scanning is a set of unstructured 3D points called point cloud.

Geographic information system enables us to manage the geo-referenced data which are given in the form of geographical coordinates in a specific geographic coordinate system (e.g. GPS). GIS presented in this article consists of a database, server applications and applications on the client side. The database is of crucial importance in the given system. Shape format (SHP) is used in geographical data. Open source platforms in the field of GIS are used for development of this e-service. Thus, we have shown that even with less expensive technology, a reliable and advanced e-service on the Internet and smart phones can be developed.

II. THE SUN POTENTIAL AND GIS APPLICATIONS

The sun potential is calculated using the method presented in [2], where multi-resolution shading, long-term daily radiation measurements and vegetation shading is taken into account. LiDAR data is first put into a grid of 1m^2 cells. Space and time dependent shading also depends on the accurate position of the sun, which is calculated using SolPos algorithm [3].

Geoserver [4] is an open-source server platform written in Java, which has excellent support for WMS and WFS standards according to OGC specification [5]. PostGIS [6] is responsible for the data part and enables support for geographical objects in the database, which is managed by PostgreSQL [7]. These technologies are used on the server side of the presented e-service. Land cadaster data of Municipality Beltinci together with the sun potential are imported into database. Gradient color scale, at which cells are painted, consists of 6 colors (black, blue, cyan, green, yellow and red). It is constructed in a way where we first find the lowest and the highest value of the calculated potential of solar cells from LiDAR data. Then, we determine the initial and final color. Other values that are 20% of the difference to the highest and lowest values are interpolated (see Fig. 1).

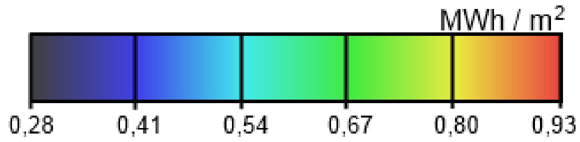

Figure 1. Example of color interpolation from 0,28 to 0,93 with step 0,13 (20%).

In the next step we create a uniformly distributed network of 1m^2 cells over the outlines of the buildings. The process is shown in Fig. 2.

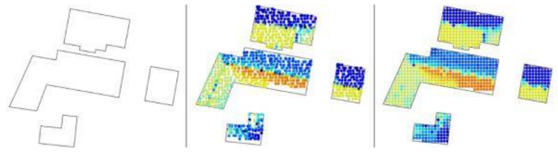

Figure 2. Example of color grid creation (left: building outline; middle: unevenly distributed cells; right: uniformly distributed

For each cell, we write the value of the solar potential and FID (FeatureID) of the building outline in the file, where each record represents a single cell. New attributes that represent the sun potential and the potential of solar PV are added to the building outlines. Created files are imported into the database on the server side, which is accessed by web application through servlets. These servlets serve as an intermediary (proxy) to connect to other services on the server. Servlets are used, for example, for obtaining information about the selected building. Example can be seen in Fig. 3.

The SolarEnergo e-service is composed of a number of applications that are needed for the accurate operation. The web application is implemented using OpenLayers library that makes it easy to work with standards like WFS and WMS [8]. To display images and orthophoto geometry WMS objects a request is sent, which returns raster data. The application allows us to select and view the details of each object by clicking on it, to which a server sends WFS request, which returns the result in the form of a GML document (Geometry Markup Language). This is converted into the OpenLayers list of geometric objects that contain all the information to describe the object (in the case of building outlines we obtain the address and street number). The application also enables search by address. As you type, valid addresses appear that match the text you entered. Selecting the result on the map shows details on the solar potential for the requested building. The web application uses JQuery, OpenLayers

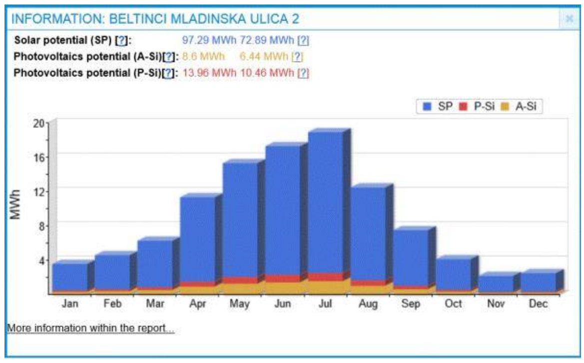

Figure 3. Example of a graph showing sun potential of a building.

and Rgraph technologies. A PDF report is also generated for each building. In addition to the basic graph about sun potential, it also includes graphs of the potential of amorphous and polycrystalline silicon PV module type. Graphs are displayed as a stacked bar chart, where the lower value is the sum of the cells above the average solar potential value, while the upper part is the difference between the total and above-average solar potential.

Today's mobile devices are increasingly powerful in hardware as well as software level. That is why we also developed a mobile SolarEnergo application supporting Android operating system. The application has the same functionality as a web application, with a streamlined search ability using the GPS technology (Global Positioning System Briefings).

The mobile application works on Android OS version 2.3.3 and newer. Because of smaller displays it is pointless to show the solar potential map and information about the selected building at the same time. This is why we divided the screen into three tabs using the "TabView" widget. To see the map in the first tab, the widget "WebView" is used, through which the page is loaded. This page has been simplified for use on mobile devices. Using the Application Program Interface "JSInterface", which is offered by the Android platform, we connect the mobile and the web applications. In this way, we can call from JavaScript, methods implemented in our mobile apps, which display data in the "Data" tab.

The mobile application enables us to find the nearest building using the current GPS coordinates. Of course, we support the search of the building through the address entry box, which has the same functionality as the web application.

Fig. 4 shows different layouts. Searching by address is shown on the left. The middle one shows a map that is the same as in the web application. The right side shows the “Data” tab with all the information regarding sun and PV potential for the whole year.

III. RESULTS

In cooperation with the Faculty of Electrical Engineering and Computer Science at the University of Maribor in Slovenia a new SolarEnergo e-service has been developed to allow citizens a graphical overview of the solar potential of buildings in local environment. Using LiDAR data of the municipality, calculation of

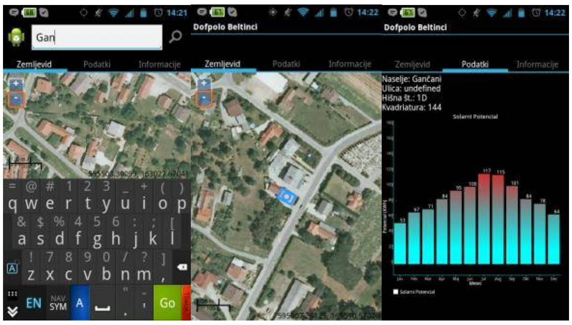

Figure 4. Mobile application on Android. Search (left), map

solar radiation and the PV potential of each building is done. The calculation method takes into account also data about direct and diffuse half-hour solar radiation over the last 10 years. Data from the nearest weather stations in the town of Rakičan was used. Fig. 5 shows a model of sun potential using LiDAR data, which is then transformed into SHP format.

When you click on the building, characteristics such as: address, street, house number, solar potential throughout the year, the potential of PV in a year for two different materials (amorphous and polycrystalline silicon) are displayed. The results, shown in the graph, are the solar potential for each month for the entire roof surface. To see the graph, a web browser with support for HTML5 technology is needed. The user has the possibility to view the PDF report, using the link located in the lower left corner of the window. When using the search by address, the view moves to the center of the selected building.

Fig. 6 shows the interface of the web application. The

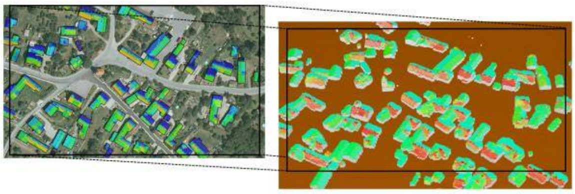

Figure 5. Example of sun potential for the same location as a WMS map (left) and as model of LiDAR data (right).

lower part shows the scale and the gradient scale of the solar potential. In the upper right corner there is the text box into which the user enters the desired address for which to display information about the solar radiation and the PV potential. Basic mapping functions, such as zoom and pan are available. The Fig. 6 also shows that the roofs facing south, have higher expected solar potential. Fig. 7 shows the solar potential of known buildings in Beltinci.

The end result is therefore a new SolarEnergo e-service for citizens, which makes it easy to select the building on a map with the help of Android smart phones and GPS. At the same time it is also possible to calculate the sun potential for the municipality as a whole, which shows the amount of energy that can be obtained on the whole territory and how it can be converted into electricity. Municipality Beltinci thus offers a new e-service, which enables everybody to directly, on the spot or in the office, get all the necessary information to decide on the usage of solar energy. SolarEnergo e-service can easily be upgraded and extended to other municipalities or also to the whole country.

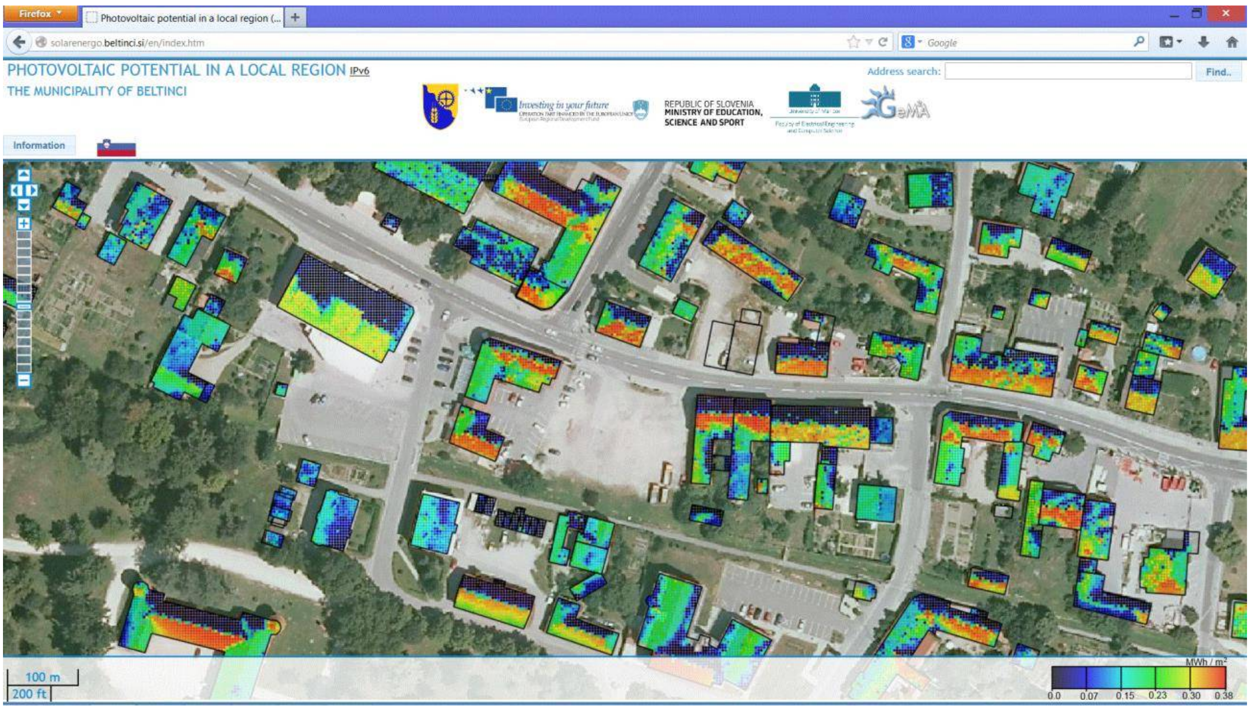

Figure 6. Final look of the web application.

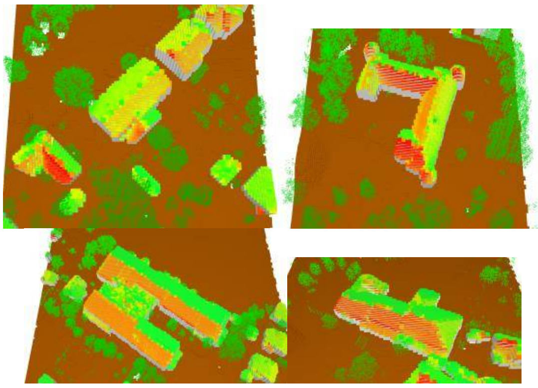

Figure 7. Sun potential of town hall (top-left), castle (top-right), primary school (bottom-left) and kindergarten (botton-right).

IV. CONCLUSIONS

In this paper we described the development and deployment of SolarEnergo e-service that allows users to visually view the solar potential of buildings in local environment. The solution provides an innovative tool for municipalities, which allows each citizen or investor to get all the necessary information concerning the investment of photovoltaic on the roofs of their buildings, at no cost. SolarEnergo e-service visually and numerically shows how much a roof is suitable for the installation of photovoltaic systems and gives a detailed calculation of the amount of solar energy throughout the year. The calculation also takes into account shading from neighboring buildings, terrain within a radius of 15 km and high vegetation. The project has successfully acquired a financial grant from the Ministry of Education, Science and Education in Slovenia for the development of innovative IT solutions. For the development of SolarEnergo, Municipality Beltinci is cooperating with the Faculty of Electrical Engineering and Computer Science in Maribor, where the Laboratory of Geometric Modeling and Multimedia Algorithms has a long history of necessary knowledge and experience to develop similar solutions in the field of geographic information systems (GIS). The system consists of free open source tools. The web application is upgraded with the mobile version, which uses GPS coordinates when selecting the nearest building to our position in the field. In this way we offer our citizens the possibility of increasingly widespread use of e-services on smart phones and their technical abilities.

Presented SolarEnergo e-service is a new step in services which a municipality can offer to its citizens. It can be easily transferred to other municipalities or to the whole country. It is an e-service for all the citizens with a great added value in usability, which is what every municipality tries to give to their citizens.

ACKNOWLEDGMENT

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