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A SOLAR CADASTRE

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Abstract

A solar cadastre is also called as a roof cadastre or a solar potential map. This solution is to provide a geo-portal for potential users, which allows to define potential of solar energy for specific locations. It is based on a Digital Terrain Model and climate information available for this area. This kind of geoportals are made mainly as an initiative of the local government of the city. The aim is to increase public awareness of the advantages of using solar energy. Analysis of sunlight and solar potential maps can be used in various fields (like civil engineering, energy engineering and spatial planning) and stage of investment. These systems should be user-friendly, ie they should clearly show the information about the energy potential of the location and facilitate decision-making in investment in solar collectors.
The aim of project was to analyse the available methods, which allow to determine the value of solar potential for the area (roof of the building) from DTM and energy possible to obtain from this area. The project shows examples of different models of the solar cadastre available to users of the world and their use. Selected solar cadastre maps available to users on the Internet since 2008 have been analysed. Then the maps were compared in terms of their usability and usefulness of the work related to spatial planning. The results will be used to create a solar cadastre concept in Poland.

***Key words**: Digital Terrain Model, solar cadastre, solar potential.*

INTRODUCTION

All fossils fuels, ascoal, natural gas and oil, are the result of plant decomposition that happened millions of years ago – under water. When a man found use for these materials, energy, within 50 years the world has changed beyond recognition. The development caused that the population has doubled,industry has developed,transport capacity has increased.Agriculture has been modernized so that developed countries produce a surplus of food. A liter of oil generates as much energy as the work of one hundred people.The current statistics show that globally, fossil fuels provide for over 85% of all the energy we consume.

Our environment is paying a high price. The increase in the concentration of CO^2 in the atmosphere causes the expansion of the ozone hole. Emission of sulfur dioxide and nitrogen from coal combustion is the cause of acid rain and smog. Great Smog, which held only a few days in 1952 led to the deaths of thousands of people. In January 2014, Beijing limit safe for health (25 micrograms per cubic meter of dust concentration in the air) was exceeded 26 times and reached 671 micrograms per cubic meter.

Oil and coal run out. First, it comes to an increase in their prices and dependence on countries that have reserves. Environmental damage because of over-exploitation will be irreversible. This could be avoided. In 1992 in Rio de Janeiro Poland participated in the Earth Summit (United Nations Framework Convention on Climate Change), so that Poland could sign the Kyoto Protocol in 1997, which talks about reducing greenhouse gas emissions.

The most important solution is renewable energy sources: sun, biomass, wind, water,geothermal power, wave and tidal power.So one of the ways to reduce the concentration of CO^2 in the air is the use of renewable energy sources, including energy coming from the Sun. (Nowicki, 2012). Figure 1 shows the annual energy consumption of humanity in 2010, compared to the size of the annual amount of energy from various

renewable sources. The colourblue is a global demand for energy. Colours red, brown, green and black are other kind of energy (wind, gas, oil, coal).

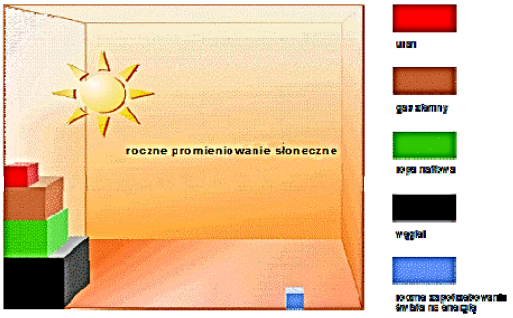

Figure 1. The annual energy consumption of humanity, 2010

Source: www.unfccc.int

Solar energy is radiant light and heat from the Sun harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis.It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the way they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

The large magnitude of solar energy available makes it a highly appealing source of electricity. The United Nations Development Programme in its 2000 World Energy Assessment found that the annual potential of solar energy was 1,575–49,837 exajoules (EJ). This is several times larger than the total world energy consumption, which was 559.8 EJ in 2012.

Poland in terms of the intensity of the radiation, if divide its territory into two parts, the south can be compared with northern France, and in the north of neighboring Germany. (Figure 2, Figure 3). Sunlight is the sum of solar radiation at the time and on the surface. It is a quantity that describes the resources of solar energy at a given place and time, it expressed in Wh/m² per day, month or year. The average amount of solar energy in Poland is estimated at approximately 900 - 1100 kWh / m2 per year. This gives the equivalent of the energy resulting from the combustion of approx. 110 m3 of natural gas or 100 liters of heating

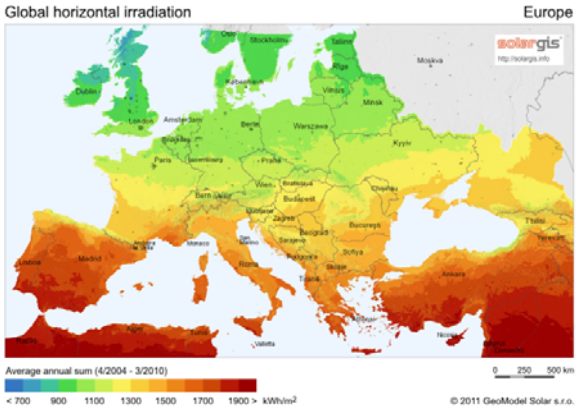

Figure 2. Global horizontal irradiation in Europe

Source: www.solargis.info

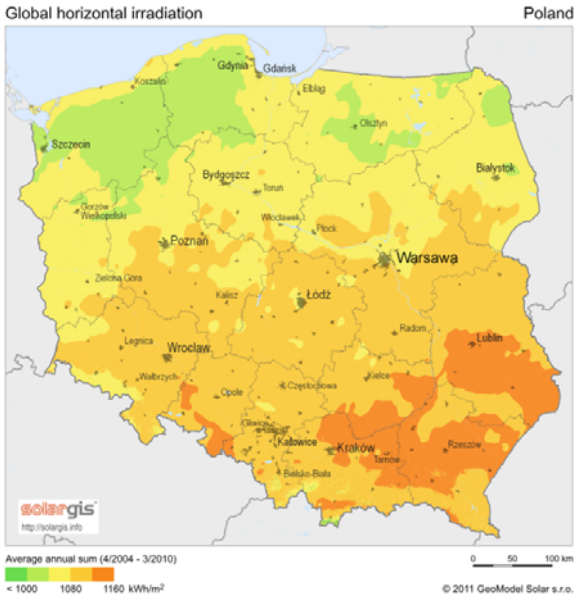

Figure 3. Global horizontal irradiation in Poland

Source: www.solargis.info

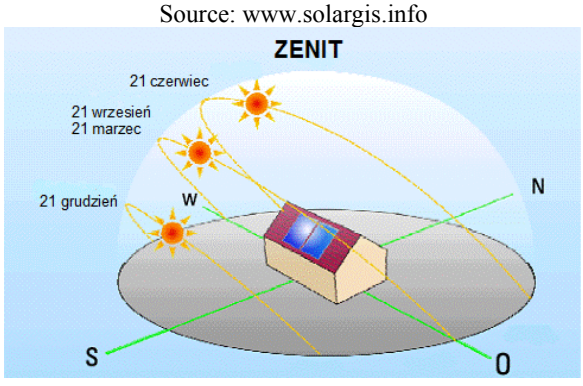

Figure 4.Sun Angle and Seasons

MATERIALS AND METHODS

In order to analyse various types of solar cadastre were used: geoportal or city GIS service, which are available on city website in Europe and in the world.
The work was prepared in several steps. First, a list of all cadastral solar was created. Then rated each system: described and evaluated their advantages and disadvantages for a potential as a user.The results will be used to create a solar cadastre concept in Poland.

RESULTS AND DISCUSSIONS

A solar cadastre is also called as a roof cadastre or a solar potential map. This solution is to provide a geo-portal for potential users, which allows to define potential of solar energy for specific locations. It is based on a Digital Terrain Model and climate information available for this area. (Table 1). This kind of geoportals are made mainly as an initiative of the local government of the city. The aim is to increase public awareness of the advantages of using solar energy. Analysis of sunlight and solar potential maps can be used in various fields (like civil engineering, energy engineering and spatial planning) and stage of investment. These systems should be user-friendly, ie they should clearly show the information about the energy potential of the location and facilitate decision-making in investment in solar collectors (Królikowski, 2011).

Table 1.Information for a solar cadastre

Information whichareneeded	
NMT	known coordinates X, Y, Z
Meteorological data	Climate data from long-term record of information on solar radiation, cloud cover, fog. Internet website of the Ministry of Infrastructure and Development "Typical summer weather and statistical climate data for the Polish territory for the calculation of energy buildings"
The algorithm for the calculation of the solar potential	Solar Radiation from Esri, (ArcGIS Saptial Analyst), GrassGISr.sun model
Server, available on the internet	Easiness and clarity "readability" for the user,
	Map makes easy to decide on the installation of correctors Information on additional permits eg. construction on the historic building

Countries such as Germany or Austria have found away how to broaden awareness of their citizens and invest in solar installations. Cities put solar map on their official website. Solar map is a geoportal, where the interested can assess whether the roof of his house is favorably located towards the sun, to install photovoltaic cell or solar collector.
In 2008, for the city of Osnabrück (Germany)
It created the first map of the solar potential. Germany and the United States are the countries that were the first in this field.List of cities currently have solar portal was presented in Table 2 along with Internet addresses, technology of calculating potential, and technology to share Web GIS.
The solar map of the city of Boston was created on the initiative of the government, whose idea is to reduce by 2020 greenhouse gas emissions to 25%. After entering the official website of the city (www.cityofboston.gov) on the menu of the page, click the link "Maps" shows a series of maps, including searched "Solar Map". On the target card shown is the goal, and the current implementation of the program. In addition to assisting the user in estimating solar energy and the representative of the potential value of the solar system, there is also set of information about solar panels and about what you need to know before installing.
The Map Solar was created in the program ArcGIS ESRI, which allows you to create, edit and analyze data. Calculation of the solar radiation is calculated in the extension Solar Analyst. Geoportal contains three overlays informing the user about [www.cityofboston.gov]:
- monument zone,
where it is necessary to obtain additional permits,
-electricity grid NSTAR, where building photovoltaic system may be limited,
-the usefulness of roof for installation, where by means of the intensity of colour from yellow to red is shown the total annual radiation on the roof.

Table 2. Solar cadastre in the world

City/Region	Web address	The technology of calculation	Technology of Web GIS
Europe and Africa	http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php	Joint Research Centre	MapServer
Austria			
Graz	http://gis.graz.at/	ArcGIS Desktop	SynerGIS, Esri ArcGIS Server
Vienna	http://www.wien.gv.at/ umweltgut/	-	bd. (część Vienna GIS)
Chile			
Calama	http://www.geopm-kom5.de/geoapp /catastrosolar/calama	Sun-Area, ArcGIS Desktop	Mapbender
Germany			
Berlin	http://www.virtual-berlin.de/	Sun-Area, ArcGIS Desktop	Google Earth (3D), Map-Guide (2D)
Bielefeld	http://www.bielefeld01.de/	Sun-Area, ArcGIS Desktop	Mapbender
Bremen	http://www.solarkataster-bremen.de//	-	-
Gelsenkirchen	http://geo.gkd-el.de/ website/solar/	AeroWest	EsriArcIMS
Hamburg	http://www. hamburgenergiesolar.de/	Hamburg Energie	OpenLayers+WMS
Monachium	http://maps.muenchen.de/	-	OpenLayers+WMS
Osnabrück	http://www.osnabrueck.de/ sun-area	Sun-Area, ArcGIS Desktop	EsriArcIMS
Zw. powiatów Neckar-Odenwald-Tauber	http://www.leader-neckar-odenwald-tauber.de	Sun-Area, ArcGIS Desktop	Mapbender
USA			
Boston	http://gis.cityofboston.gov/ solarboston/	ArcGISDesk	EsriArcGIS
Denver	http://solarmap.drcog.org/	Woolpert Inc., NREL	Google Maps API
Los Angeles County	http://solarmap.lacounty.gov/	CH2M Hill, NREL	Bing Maps API
San Francisco	http://sfenergymap.org/	CH2M Hill, NREL	Google Maps API

Figure 5. The solar cadastre of Boston city – ortophotomap

Source: www.cityofboston.gov

Figure 6. The solar cadastre of Boston city - map

Source: www.cityofboston.gov

The map shows, where there are places of existing installations. After moving the cursor on the symbol ("sun"), show the data on location, type of solar energy system, power, and also the company which installed it. Some descriptions are enriched with a picture of a building with installed solar collectors or solar cells. The user can calculate also solar potential for selected area.

Figure 7. The solar cadastre of Boston city – calculation of solar potential

Source: www.cityofboston.gov

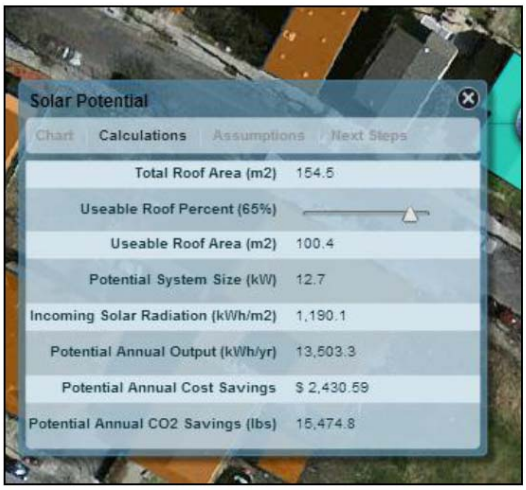

Figure 8. The solar cadastre of Boston city – "Calculations"

Source: www.cityofboston.gov

Geoportal unfortunately created a model of the detail CityGML LoD110, which assumes that each roof is flat. This is a big minus. Installations with sloping roof facing to the north do not agree.It is true that the tabs for solar calculations, calculated the surface area which is suitable for development, but included here are only obstacles, for example in the form of chimneys. The roof is further adopted as a flat. The result is that the user must ask for help from specialist companies to install solar installation in his home.

Solar geoportal for Vienna, is placed on the official website of the city in the "Umweltgut." The program includes the potential of solar energy for the production of heat and electricity.Solar cadastre was created through the use of ALS data saved in the form of GRID (mesh opening of 0.5 m). Finding the web application and its use, it is very easy for a potential user. The program assesses the orientation and slope of the roof, shading caused by plants, buildings, and terrain. Direct radiation and scattered radiation from the period of 18 years, were averaged. On the map shown is only sunlight above 900 kWh / m2 [www.wien.at].After clicking the cursor on a specific building, it shows the information about the solar potential of this building (Figure 9).Solar Portal for Vienna based on the model takes into account the actual shape of the roof, determined on the basis of detail CityGML LOD2, so we know exactly which part of the

roof is suitable for installation. Innsbruck Laser DaneGmbH is a company that made a map of the solar potential for the Austrian capital. This is one of the best prepared, clear and having much information solar map. Anyone interested in installing the solar installation can also read from it,if he needs some additional permits for the construction or must adhere to specific laws.

Figure 9. The solar cadastre of Vienna city (Wien Umweltgut: Solarpotenzialkataster)

CONCLUSIONS

As shown there are different types of solar cadastre. The differences result from the selection of data, detail of the model, the information provided on the site, layout of the page. All, however, are designed to promote the use of renewable energy from the Sun and estimate the efficiency of future installation.
In Poland, unfortunately, no city does not have an Internet portal, which are placed the solar potential map.

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