Application of geomatics in photovoltaics

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ملخص: تكشفُ الأمم المتحدة في تقريرُها المتعلق بحماية المناخ عن استخدام أكبر مصدر من مصادر الطاقة المتجدّدة. في بداية هذه القائمة الأنظمة الفوتوفولتكية التي تُولّدُ القوّة من الطاقة الشمسية بشكل موثوق وبدون أيّ تأثير على البيئة . للإستغلال هذه الفوائد بشكل مثالي يجب أن تحدد و توجّه الأ نظمة الفوتوفولتكية بشكل صحيح في البيئة لمُطابقة المواصفات المطلوبة (زمن العزل، منطقة التوجيه، المعطيات القانونية، قوة الشبكة الساكنة و/ أو الديناميكية إلخ) لتبرير إستعمال الأنظمة الفوتوفولتكية بطريقة إقتصادية طبقت الجيوماتية تبعا للقرارات . عزّزت سلوفينيا في السنوات الـــ15 الماضية النظام الوطني للبناء التحتي Geoinformation المستعمل على نحو واسع في القطاع الحكومي و الخاصّ في مختلف التطبيقات الموضوعية و المشروع الموجّه . تبيّن هذه المساهمة تطبيق قاعدة معطيات الجيوماتية الوطنية القياسية للبناء التحتي في مجال الفوتوفولتايك . إنّ إستعمال قواعد المعطيات مثل العزل، نموذج المنسوب رقمي ، صور ذات الإسقاط العمودي الرقمي، سجل أراضي الأرض ، سجل أراضي البنايات ، سجل أراضي وسائل البناء التحتي ، و المخططات الفضائية لحماية البيئة الموصوفة بالتفصيل تُشيرُ إلى دورهم في عملية تحقيق الأمثلية. كل العملية مدعومة بالأمثلة العملية بما في ذلك المكوّنات التقنية والإقتصادية .

الكلمات الأساسية: المناخ، بيئة، تطبيق، GIS، نظام ثلاثي الأبعاد، طاقة شمسية، فوتوفولتيك.

Résumé : Le rapport des nations unies sur le climat montre que pour sauver le climat il faut utiliser les plus grandes ressources d'énergie renouvelables. En tête de cette liste les systèmes photovoltaïques qui produisent sérieusement la puissance de la lumière du soleil et sans aucun impact sur l'environnement. Pour exploiter ces avantages optimalement les systèmes photovoltaïques doivent être correctement-localisés et orientés dans l'environnement pour répondre aux caractéristiques techniques exigées (temps d'isolement, zone d'orientation, législation de données, réseau de puissance statique et / ou dynamique etc.). Pour justifier de manière économe l'usage des systèmes photovoltaïques la géomatique a été appliquée dans par décision. La Slovénie a systématiquement dans les 15 dernières années, développée le système national d'infrastructure geoinformation qui est utilisé beaucoup dans le secteur gouvernemental et privé pour les différentes applications thématiques et projet orienté. Cette contribution montrerait l'application de la base de données géomatique nationale standard d'infrastructure dans le domaine de la photo-voltaïque. L'usage de base de données tel que l'isolement, modèle d'élévation numérique, orthophoto numérique, le cadastre, cadastre de constructions, cadastre des équipements d'infrastructure publique et les plans spatial de protection de l'environnement sont décrits en détail en indiquant leur rôle dans le processus d'optimisation . Le processus entier est soutenu par des exemples pratiques y compris les composants techniques et économiques.

Mots-clés: Climat, Environnement, Application, GIS, Système à trois dimensions, Énergie Solaire, photovoltaïque.

Abstract : The United Nations climate report discloses that saving the climate is to make greater use of renewable energy resources. On the top of this list are photovoltaic systems generating the power from sunlight reliably and without any impact on the environment. To optimally exploit these advantages the photovoltaic systems must be properly located and oriented in the environment to meet the required specifications (insulation time, area orientation, legislation data, static and/or dynamic power network etc.). To economically justify the use of the photovoltaic systems the geomatic was applied in the decision making process. Slovenia has in last 15 years systematically built up the system of national geoinformation infrastructure which is widely used in governmental and private sector for different thematic and project oriented applications. This contribution would like to show the application of the standard national geomatic infrastructure data base in the photovoltaic domain. The use of the data bases such as insulation, digital elevation model, digital orthophoto, land cadastre and land register, cadastre of buildings, cadastre of public infrastructure facilities and environmental spatial protection plans is described in detail indicating their role in the optimization process. The entire process is supported with practical examples including the technical and economical components.

Key words : Climate, Environment, Application, GIS, Three-Dimensional System, Solar Energy, Photovoltaic.

1. Preface

1.1 Solar energy

The solar illumination radiation of Slovenia was elaborated by the quasi-global radiation model. Solar energy depends on the incidence angle (astronomical

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and terrain conditions) and on the duration of solar radiation. The annual global and quasi-global radiation energy was calculated as the sum of all energies over all decades. (Figure 1).

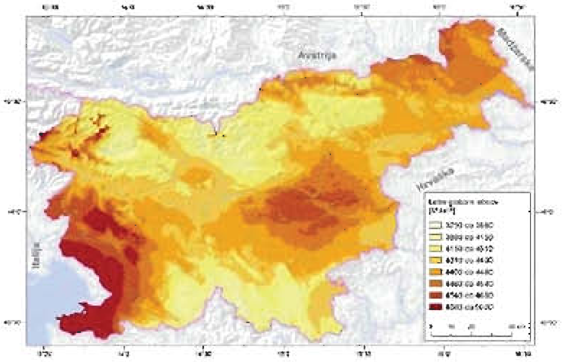

Fig. 1 Energy of annual global radiation in Slovenia.

1.2 Photovoltaics

Photovoltaics is a solar power technology that uses solar cells or solar photovoltaic arrays to convert sunlight directly into electricity. Photovoltaics is also the field of study relating to his technology and there are many organizations devoted to work on photovoltaics. The manufacture of photovoltaic cells has expanded dramatically in recent years. Mostly the installations are grid-tied, ground-mounted or building-integrated. (Figure 2)

Fig. 2 Ground-mounted and building-integrated photo-voltaic arrays.

1.3 Geomatics infrastructure

In last 15 Years Slovenia has build up numerous geoinformation infrastructure databases ranging from property registers, technical infrastructure databases and various registers to support the management of the real estates. The entire geo-infrastructure follows international standards and is governmentally owned. Figure 3 shows few examples of geomatic databases.

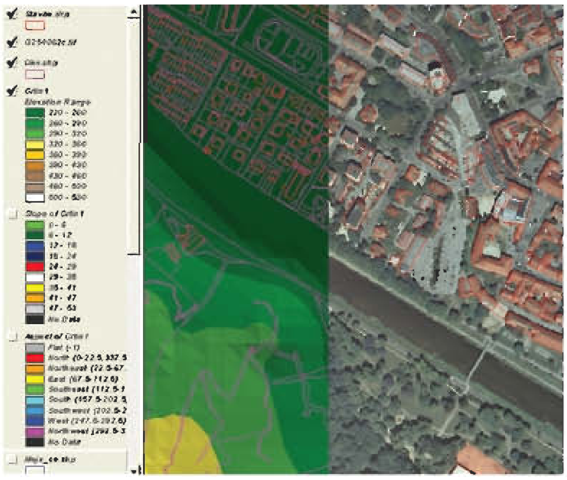

Fig. 3 Land cadastre, cadastre of buildings, digital terrain model and its optional derivatives (slope inclination and orientation). DOF.

2. Legal basics

The basics for the realisation of entire European Union climate- energy package of measures (worth 60 billion €) are action programmes which have to be ratified by national parliaments. In this context Slovenia will have to increase the part of renewable energy resources by 2022 from 16% to 25%. This way European Union will decrease the external dependence from oil and gas and essentially increase energy security.
One of the most important alternative sources of energy is photovoltaic which essentially contributes to friendly European environment.

3. Problem definition

In order to identify the necessary geoinfrastructure databases, the entire process of operational photo-voltaics had to be defined. The process comprises 2 steps. In the first run the estimation of the entire technical feasibility and economical investment are elaborated. If the estimation is positive then the second run is realised which brings the project to the operational production of electrical power.
This paper has the intention to show how the geomatics is used in the first run in order to produce reliable technical and economical results for later actual execution of the project. The following abbreviations are used in the process diagram for the geo databases :

- solar illumination radiation – SIR
- land cadastre and land register – LCLR
- cadastre of buildings and land register – CBLR
- environment protection plan – EPP
- public infrastructure – PI
- digital terrain model – DTM
- digital orthophoto - DOF
- topographic data / buildings - TDB

Figure 4 shows the process diagram of the photovoltaic project and identification of the geomatic databases.

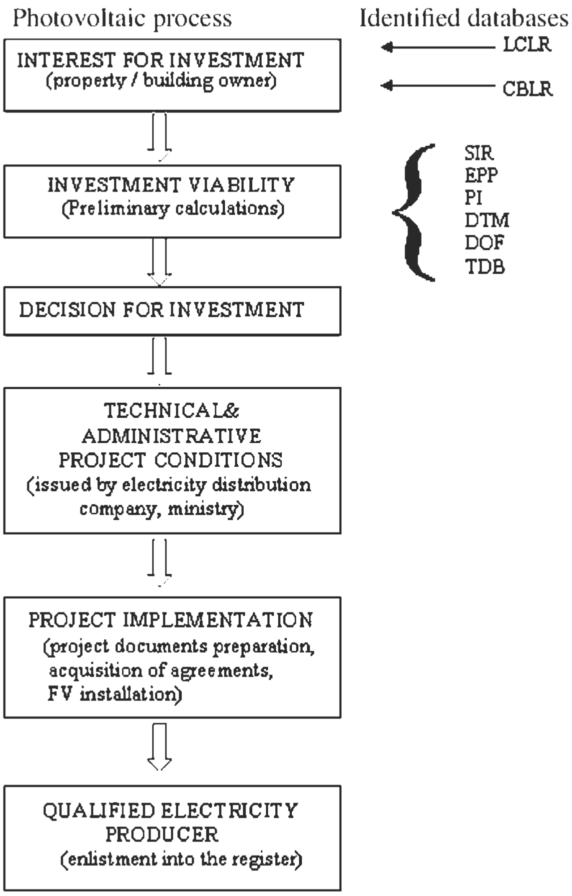

Fig. 4 Photovoltaic process and geomatic databases.

4. Determination of components

4.1 Determination of the object

The object under consideration is determined either from land cadastre or from cadastre of buildings with necessary attributes. The ownership is identified from land register.

Sid	25320134
H1	248.00
H2	254.96
H3	236.92
X_coord	520588.00000
Y_coord	120610.00000
Parcele	2403
Area	425.235
Sifko	1077
Owner	Community Celje

Fig. 5 Determination of the object (cadastre of buildings with DOF, selected attributes from cadastre of buildings and land register).

4.2 Determination of the solar radiation

The solar radiation is determined from the solar radiation database. Solar radiation is determined in $MJ/m^2/year$. It depends on the location of the object in the particular radiation zone. Medium values for those 4 zones are varying from 3700 to 4500 MJ.

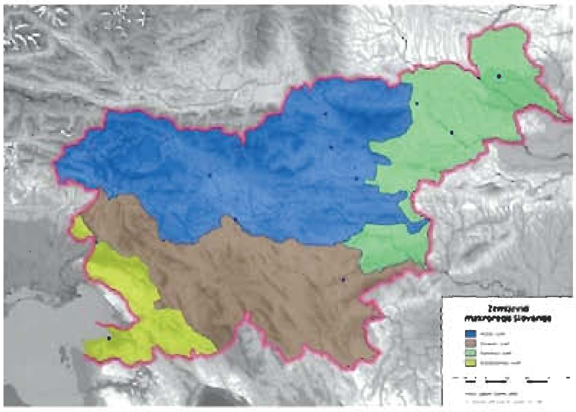

Fig. 6 Solar determination radiation regions (alpine, dinaric mountain, panonian basin and Mediterranean region).

4.3 Area of the object

In case of the parcel, the area is determined directly from land cadastre. If the object is building the area of the roof is determined directly from cadastre of buildings or by counting the pixels (0,5m x 0,5m) in digital orthophoto. In both cases the area has to be corrected by the inclination factor.

Fig. 7 Area determination.

4.3 Azimuth

Azimuth determination for parcels is determined by digital slopes orientation database.

The azimuth of the roof can be determined through computation based on the measured coordinates of the relevant points on the roof. Due to simplicity the azimuth in the operational photovoltaic system is defined just by overlaying a compass based diagram on the displayed object. The reading is recorded manually.

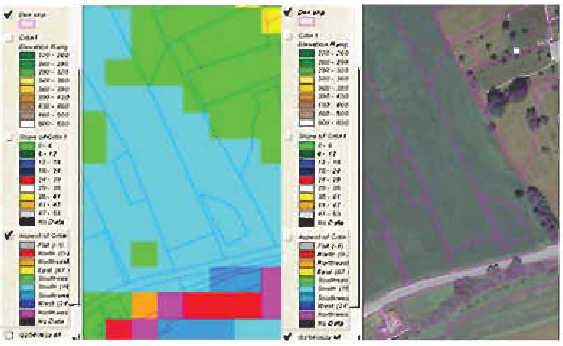

Fig. 8 Azimuth determination for parcel.

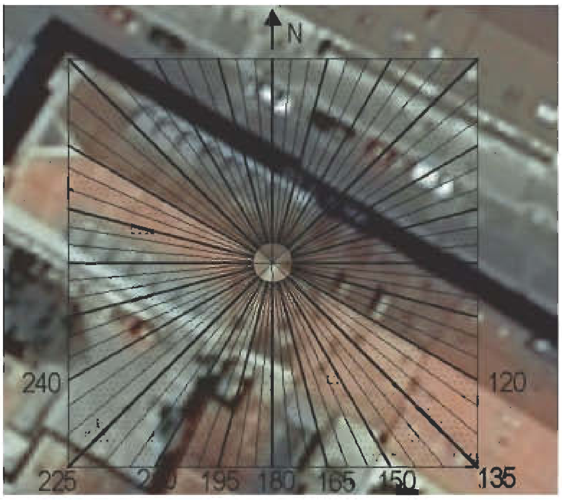

Fig. 9 Azimuth determination for object.

4.4 Inclination

Inclination of the roof is determined by using formula

$$tg\alpha = \frac{b}{a}$$

where b = roof height obtained from the cadastre of buildings
a = horizontal component of a steep, measured from DOF

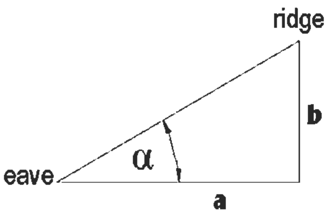

Fig. 10 Inclination determination.

4.5 Determination of solar energy for the object

To properly estimate the effect of inclination angle and azimuth the relevant diagram was generated for northern latitude of 45 degrees. The diagram defines the approximate percentage areas of solar energy in dependence of inclination and azimuth.

Now, the total solar energy on the object can be computed as follows :

$$SE_{total} = SE \cdot Area \cdot IA$$

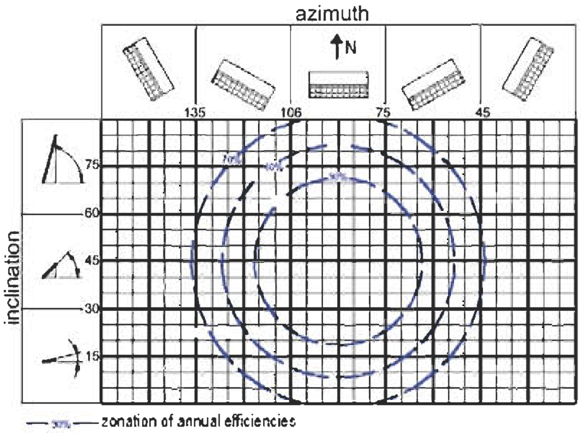

Fig. 10 Solar energy as the function of inclination and azimuth.

where SE_{total} = Total solar energy [KW/day]
SE = Solar energy in Slovenian zone [W/m^2 /day] Area = area of the object [m^2]
IA = Solar energy as the function of inclination and azimuth [%]

With determined SE_{total} it is now possible to estimate the economic viability of the potential solar power plant. If the result is positive further computations take place regarding technicalities of the entire project. If, again, the results are positive the actual elaboration of solar power plant takes place having all necessary economic, legal and technical implications.

5. System operationality

The main goal of this project was to equip the photovoltaic engineers with fast and reliable tool to estimate the economically viable conditions for potential solar power exploitation. More detailed computations are made during project documents preparation. Therefore the operations are kept as simple as possible allowing effective relevant computations (the entire process requires at max 10 minutes). On the other hand the geoinformation infrastructure proves to be extremely usable especially in the domain of time and costs savings.

6. Future developments and recommendations

It must be emphasized that the described application of the geomatics is one of many being already operational. These are ranging from communities to enterprises management, support to water and energy supply, environment protection and many others. But as the rule of thumb we have to bear in mind that potential applications will only be successful if the user processes are clearly defined allowing optimal use of geomatics.

Bibliographie

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