GEOGRAPHY AND SOLAR ENERGY UTILIZATION

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Abstract: *Nowadays, the questions of energetic safety are frequently discussed issues. One of the possibilities is the diversification of production of energy with more utilization of renewable energy sources (RES). The most perspective is the utilization of solar energy directly in urban areas, typical for their biggest demand for energy. It is obvious that application of solar systems is dependent on qualitative analyses concerning a variety of relevant questions (amount of energy falling down to surface, atmospheric influences, economical questions etc.) Therefore many sciences deal with energetic utilization of solar energy. This paper tries to find the position of geography in energetic utilization of solar radiation.*

Key words: *solar energy utilisation, geography, geography of utilisation of solar radiation*

INTRODUCTION

Continuously increasing demand of energy, longtime improving of costs of energy sources and energy, many problems with transportation and geopolitical instability are the reasons, why we have to think about questions of energetic security. Additionally, in the last time, mainly since the nineties of 20 century, a negative impact of the energy segment of economy on the environment is also very often discussed issue, which is related primarily to ensuring ecologically sustainability of landscape. To avoid a possible energetic crisis, it is necessary to diversify energy production. One of the most perceptive possibilities is to give greater scope to renewable energy sources (RES). The issue of wider use of RES includes the priority themes of the European Union, which is included in several of its decisions and laws. New motion in energy policy of the European Union is to increase the proportion of energy derived from RES to 20% by 2020.

The basic starting point for finding the optimum solution of RES utilization is the fact that the most energy consumption is in urban country, with the highest concentration of population on a relatively small area. From the available RES the most beneficial in the urban country may be the solar energy, for several reasons - the energy has a significant and pervasive technological potential, low operating cost, zero negative environmental impacts during operation, it is not entitled to a newly built area, there are also the possibilities of interesting architectural buildings, it enables to produce electricity directly or it can be used for water heating, or even for cooling and so on. (Kaňuk, 2007) In terms of effective use of solar energy systems and the installation (equipment producing heat or electricity from solar radiation) the roofs of buildings seems to be very perspective.

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Although the price of solar energy systems and other related infrastructure has rapidly decreased in the last 10 years, massive installation of solar energy systems will undoubtedly require a significant financial investment. Therefore, significant role in a planning stage has the quality of analysis, which should be orientated to particular aspects of spatial and temporal distribution of solar radiation, sunshine spatial aspects of installations, technical and technological aspects of solar energy systems, energy requirements of population, investment and legislative support, etc.

These facts motivate researchers of many disciplines in various institutions that have proven as accurate as possible to reflect the technological, economic, and available potential of solar energy, as well as to streamline the actual production of energy from the sun radiation, try to find an optimal installation models, contribute to solution of energy security and attend to enquiries of other relevant aspects.

APPROACHES OF SOLAR RADIATION RESEARCH IN TERMS OF ENERGETIC EFFICIENCY

As noted above, the issue of energy use of solar radiation in the urban country is an actual topic of several scientific disciplines. Every science has its own object, research field, methodology, paradigm system and theory. Each of them has its own different view on solar energy utilization. This specialization of sciences has its importance, because it is necessary to deal with many phenomena related to solar energy utilization in the urban country (e.g., solar radiation, solar radiation transition through galactic environment and atmosphere, the position of the Sun as a source of solar radiation and the Earth and relevant temporal and spatial aspects, atmosphere and local climate, meteorological phenomena in the atmosphere, solar systems and the efficiency of conversion of solar energy, power and electrification system, construction and architecture, marketing, and demand for solar energy systems, legislative and investment promotion, energy consumption and psychological aspects of RES equipments - NIMBY syndrome). These aspects of solar radiation usage and installation of solar energy systems are vitally dependent on developing high-quality analysis.

In the research of solar radiation in terms of its energy utilization there are several disciplines included that could be categorized to:

1. natural sciences
2. technical sciences
3. social sciences

Natural sciences deal with research of energy utilization of solar radiation in terms of enquiry to the generation and spread of solar radiation, its immanent substance, energy value, solar radiation passage through the atmosphere, atmospheric phenomena affecting the energy value and distribution of solar radiation and the like. All these aspects of research could be covered by the **sciences with physical base**, which include the atmospheric sciences (climatology and meteorology), thermodynamics, optics and astronomy (astrophysics, astrometry). Climatology and meteorology are the sciences which have the largest share of the physical sciences participating on the utilization of energy especially solar radiation. Significant works in this area in the domestic literature include Hrvoľ and Tomlain (1992, 1997 a, 1997 b), Smolen (1980), Ostrožlík (2002), Kittler and Mikler (1986), Kittler and Pulpitlová (1988) and others, from foreign pointers

work Zelenka et al. (1992), Hulme et al. (1995) and others. In this context it is necessary to say that the physics constitutes the basic knowledge of energy utilization of solar radiation being an very important part, also transferred to other disciplines.

In the group of natural sciences, which are significantly involved in terms of energy of solar radiation, spatial relationships, modeling and statistical analysis of the attributes relevant to the energy utilization of solar radiation, there are also **mathematical sciences**, and especially geometry, mathematical analysis, topology and statistics. In scientific literature, we can find many works that use scientific methods based on modeling, statistical analysis and visualization in cyberspace, which is implemented in specialized information systems or into GIS. Documented to works for example Neteler and Mitasova (2004), Suri (2002), Dunlop et al. (2003), Hofierka (1997), Hofierka and Šuri (2004), Suri et al. (2007), Hengl and Reuter (2008), Muneer (2004) and others. The most significant share in this research has geostatistics and geoinformatics, which uses a whole range of instruments of GIS (Geographic Information System) (Hofierka, 2003). The latest trends are orientated to provide information about solar radiation and its energetic value on the internet in the form of web-database with interactive maps, tables and graphs of energy derived from sunlight, where it is possible to specify the parameters of the position, angle modules and orientation towards the cardinal points. (Šuri et al., 2005). Information and communication methods and tools, therefore allow us to create cyberspace, where it is possible to simulate the distribution of solar radiation as well as other aspects related directly to the estimated use of energy (digital model of topography, clouds, etc.).

Geoecology and environmetanlistic are included in the group of natural sciences having their research focused primarily on the issue of reducing CO_2 output as well as the creation of environmentally sustainable country (Laurman, 1979, Šenitková and Eštoková, 2002, Drdoš, 1997 and others).

Another important insight into the research of solar radiation for energy purposes are **technical sciences**, integrating architecture, construction, and electrical energy.

Architecture and Construction is devoted primarily to solar radiation as a phenomenon in the form of heat and light, which has greatly influenced the energy regime and the operation of apartment buildings as well as industrial buildings, and buildings with administrative, commercial leisure and other function (Littlefair, 2001), (Pereira et al., 2001), (Eifert a Kiss, 2002), (Garcia et al., 2007). Among the major investigators of this issue we include the authors, we have already mentioned in the physical sciences, but their work has a direct connection with the construction and architecture. They are Kittler and Mikler (1986), Kittler and Pulpitlová (1988), whose works have found an international response.

Electrotechnics and energetics focuses on the development of such systems that can convert sunlight to usable energy form as well as use of produced energy in the energy system. This issue is examined in many works, eg. Rybak, Tauš, Rybak (2001), Tauš et al. (2005), Ružinský and Šály (1996, 2005), Smola (1980), as well as numerous publications of foreign authors as Turrent and Baker (1983), Marks (1965), Quaschning (2003), Muselli et al. (1999) and others. Research activities in the field of development of technologies to generate energy from solar radiation and their testing is carried out in research institutions around the world (eg Join Reserch Center (JRC) in Italy - the EU, National Renowable Energy Laboratory (NREL) in the U.S.), in companies involved in the evolution of the solar

systems (eg ThermoSolar Žiar nad Hronom, ...), as well as at universities (in Slovakia, such as the Technical University of Kosice, STU Bratislava, Žilina University in Žilina, etc..) (Potocký and Hofierka, 2006).

Even the **social sciences** participate on the energy use of solar radiation particularly there are economics, marketing, sociology, urban planning, demography, and legal sciences. Economy gives answers to questions like - how much energy to produce; respectively what is the demand for energy, for whom to produce energy from the sun, what is the efficiency of energy production and thus whether the production is worthy, what is the return of invested funds and the like. These problems are also outlined in the works of Jäger-Waldau et al. (2006), Šúri (2006) and many internet sites devoted to the applications of solar systems (e.g. www.ozeport.sk, www.setri.sk and others). Marketing is linked directly to the applications in the country. Thus, together with the sociology it examines the behavior of the population in relation to the application of the solar systems and gives answers to questions like - which people are interested in these technologies to reach other population groups, as are mental barriers in the application of solar energy systems and how to remove them, etc. .

Law sciences participate in the application level, where they deal with questions like - how to remove the legislative barriers and create a challenging environment that would favor numerous installations. In this sense, we have to mention current legislative background supporting the use of energy from solar radiation, which is based on EU legislation (e.g. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market, Directive 2002/91/EC on the energy efficiency of buildings and strategic document COM/2007/723 European strategic energy policy) and Slovakia in the approximation adopted in its legal system (e.g. Act 656/2004 on energy and the change some laws, the Government Regulation No. 124/2005 laying down rules for the functioning of the electricity).

The following chart shows the participation of sciences on the solar energy utilization and the position of geography.

POSITION OF GEOGRAPHY

Geography has the assumptions to play a significant role in the research of solar energy utilization. Planning and solar energy use is largely dependent on the quality of temporal and territorial analyses. Basically, we can say that for geography is the space and its time regularities a phenomenon, which requires most of its attention and all the research activities are focused on it. To explore the space it is a geographical science that has a detailed methodological system for examining the attributes of temporal and territorial-relevant research on the solar energy use. In this context it is necessary to note that geography has not an ambition to compete with the sciences dealing with technical and technological attributes of the solar systems, respectively other related infrastructure, research solar radiation in terms of its spectral electromagnetic nature, nor a detailed examination of atmospheric phenomena, which also significantly affect the efficiency of conversion of sunlight to some form of energy and so on. Geography directs its research activities to the space and the potential valuation of landscape for application of solar systems.

Geography is seen in the works of Demek (1987), but also Paulov (1998), Matlovič (2006) and Hofierka (2006) as a synthesizing science, whose object of research is fully oriented on the whole landscape sphere. Therefore, its application in relation to the topic can be discussed also in the urban area in the interaction with the socio-economic activities of the population, which is directly related to energy consumption and possibilities of its production, energy saving and rationalization of the energy segment. In this context, a morphological-functional regionalization of urban space plays a significant role. Morphological-functional analysis of urban areas, demographic and socio-economic analyses are also important for planning and decision-making phase, whereas we give answers to questions like - where is the appropriate application of solar systems, what are the demands for energy by the population in carrying out their routine needs (in terms of daily, seasonal, annual operation), what is the potential for possible areas of energy production, how to optimize and fault energy production systems and the like. Moreover, the geography helps to solve the problem also through the GIS visualizations.

In Slovak geography there have already been the works on the use of geography in the field of energy, introduced primarily by Szőllőz (1998, 2006a, 2006b). The energy uses of solar radiation in terms of geography are described in the number of works for example by Hofierka and Cebecauer (2007, 2008), Šúri (2002), Šúri et al. (2002), Hofierka and Kaňuk (2008), Kaňuk, Rosic and Hofierka (2008), Kaňuk (2007, 2008) and others, concerning mainly with the territorial-temporal distribution of solar radiation and its modeling using GIS tools. In the geographical literature we can find also the works, which are devoted to clarification and specification of distribution of solar energy conversion to georelief, for example Krcho (1990) and Jenčo (1992). In recent years geographic focus of the research has shift from a regional perspective (e.g. the European Solar Radiation Atlas - (Scharmer and Grief, 2000)) to detailed studies of urban environments, for example by Robinson and Stone (2004), Arbois et al. (2008), Hofierka and Kaňuk (2008). In this context, it is needed to note the works dealing with the use of geographic information systems in order to estimate and review the potential use of solar radiation (Šuri et al., 2002), (Gadsden et al., 2003) etc.

From the relevant analysis it is clear that the massive solar energy systems will be applied particularly in the urban (or built-up) territories, where the most developed countries have more than 80% of the population. Some authors (eg, Jäger-Waldau et al., 2006, Šúri et al., 2007) emphasize that theoretically can be the consumption of electricity in many countries completely covered by using of solar radiation for a relatively small area (in some countries it is only 1% of their territory). According Kaňuk (2007) the potential of Slovak urban country is high. Urban country has approximately 22 000 hectares of flat roofs, to which it is possible to install solar systems, which represent approximately 0.44% of urban areas. The following analyses prove that in near future it is necessary to deal with the issue of spatial and time relations in the country as well as in urban country in more details, and therefore it is the geography that can apply its research methods in this issue.

CONCLUSION

The energy utilization of solar radiation is currently the issue with increasing attention of the public. The research of solar energy is interdisciplinary and its direct application in the country is very complicated. This is the reason why related sciences must participate

and focus their attention on those aspects of the research, which are incorporated in their methodology.

The main aim of this paper was to point out on the approaches participating on the utilization of solar radiation in the country for energy purposes, as well as to seek for the application of geography in the research of solar energy radiation from the energy aspect. It is also necessary to know the sciences which contribute to the study of solar energy utilization. Sciences can be divided into three groups according to various approaches to solar energy utilization. The natural sciences are the first group concerning mainly with the physical nature of solar radiation, its generation, and dissemination of the galactic and atmospheric environment, relations of time differentiation of its distribution, etc. as well as the mathematical expression of these patterns and relationships. Specific group of natural science is represented by geoecology and environmentalistics.

The second group consists of technical sciences as an informatics, architecture, construction, energy and electrical engineering. These sciences are devoted to solar radiation in terms of energy regime of buildings (architecture, construction), as well as the development of technologies that can most efficiently convert solar radiation to a suitable form of energy and exploit it (energy, electrical engineering). Informatics is closely linked on Geoinformatics, which uses GIS for analysis, modeling and visualization of the attributes relevant to the discussed issue.

Even the social sciences are applied in the energy use of solar radiation through the economics, marketing, sociology, urban planning, demography, and law. Economics analyzes the profitability and economic returns on installed systems, marketing and sociology in particular are involved in examining the behavior of the population and a positive perception of potential solar applications, because negative perception of the installations in some regions can be an obstacle for the installation of the solar systems (NIMBY syndrome). The law helps to create a favorable legislative background.

The application of geography in the solar energy utilization is carried out mainly by creation of spatial and time analysis of attributes, on which the sun application systems are based. Moreover, the position of geography is in the intersection of natural, technical and social sciences. Its object of study is based on comprehensive socio-economic activities, including population, and therefore it can use its full range of research methods in the energy use of solar radiation and communicate with other sciences participating in this research. Geography is not regarded to be a superior science, but rather one of several sciences participating on the solar energy utilization.

This paper tries to find answers to the questions, where is the real position of geography in terms of solar energy utilization.

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References

ARBOIT, M., DIBLASI, A., FERNA´ NDEZ LLANO, J.C., DE ROSA C. (2008): Assessing the solar potential of low-density urban environments in Andean cities with desert climates: The case of the city of Mendoza, in Argentina. Renew Energy, dostupné na internetovej stránke www.sciencedirect.com/ (navštívené 12.3.2008)

DEMEK, J. (1987): Úvod do štúdia teoretickej geografie. SPN. Bratislava, s. 248

DRDOŠ, J. (1997): Geoekológia a enviromentalistika, I.časť, Krajinná ekológia, krajina, životné prostredie, Fakulta humanitných a prírodných vied Prešovskej univerzity Prešov, 153 p., ISBN 80-88722-69-1

DUNLOP, E. D., ŠÚRI, M., HULD, T. A. (2003): Photovoltaic Potential Assessment to Support Renewable Energies Growth in 10 EU Candidate Countries. In Gottschalg, R.. (ed.) Proceedings of the Conference C79 of the Solar Energy Society CREST "Photovoltaic Science, Applications and Technology", Loughborough University (UK) 3.-4.4.2003, pp. 1007-1016.

EIFERT, P., KISS, G., J. (2002): Building Integrated Photovoltaic Designs for Commercial and Institucional Structures, A Sourcebook for Architects and Engineers. NREL/BK-520-25272 dostupné na internetovej stránke www.doe.gov/bridge (dokument 25272)

GADSDEN, S., RYLATT, M., LOMAS, K. (2003): Putting solar energy on the urban map: a new GIS-based approach for dwellings. Solar Energy 74, pp. 397–407.

GARCIA, J., O., GAGO, E., J., BAYO, A., J., MONTES, G., M. (2007): The use of solar energy in the buildings construction sector in Spain. Renewable and Sustainable Energy Reviews, Volume 11, Issue 9, December 2007, Pages 2166-2178

HENGL, T., REUTER, I., T. (2008): Geomorphometry, Concepts, Software, Applications. Institute for Enviroment and Sustainbility. Join Research Centre, Trento.

HOFIERKA, J. (1997): Direct solar radiation modelling within an open GIS environment. Proceedings of the Joint European GI Conference 1997, Vienna, 575-584.

HOFIERKA, J., CEBECAUER, T. (2007): Priestorová a časová distribúcia slnečného žiarenia na georeliéfe Slovenska. Zborník medzinárodnej vedeckej konferencie "Bioclimatology and natural hazards", 17.-20.9.2007, Poľana nad Detvou, Slovensko, Slovenská bioklimatologická spoločnosť, Technická univerzita vo Zvolene, ISBN: 978-80-228-1760-8.

HOFIERKA, J., CEBECAUER, T. (2008): Spatially distributed assessment of solar resources for energy applications in Slovakia. Acta Facultatis Studiorum Humanitatis et Naturae Universitatis Prešoviensis. Prírodné vedy, Folia Geographica 12, pp. 97-114.

HOFIERKA, J., KAŇUK, J.(2008): Assessment of Photovoltaic Potential in Urban Areas Using Open-Source Solar Radiation Tools. Submitted to Renewable Energy.

HOFIERKA, J., ŠÚRI, M. (2004): A New GIS-based Solar Radiation Model and Its Application to Photovoltaic Assessments. Transactions in GIS, 8, 175-190.

HOFIERKA, J. (2003): Geografické informačné systémy a diaľkový prieskum Zeme. Vysokoškolské učebné texty: FHPV PU v Prešove.

HOFIERKA, J. (2006): Problémy súčasnej Slovenskej geografie a možné riešenia Acta Facultatis Studiorum humanitatis et Naturae Universitatis Presoviensis, Folia Geographica. 9, s. 86 - 91

HRVOĽ, J., TOMLAIN, J. (1992): Globálne žiarenie na rôzne orientované sklonené plochy na území Slovenskej republiky. Štúdia X., roč. VI., Slovenská bioklimatologická spoločnosť pri SAV, Bratislava, 124 s

HRVOĽ, J., TOMLAIN, J., (1997 a): Globálne žiarenie na území Slovenska za obdobie 1961-1990. Bulletin Slovenskej bioklimatologickej spolocnosti SAV, XVI, 26, 3-17.

HRVOĽ, J., TOMLAIN, J. (1997 b): Žiarenie v atmosfére, Polygrafické stredisko UK Bratislava.

HULME, M., CONWAY, D., JONES, P.D., JIANG, T., BARROW, E.M., TURNEY, C.A., (1995): 1961-1990 climatology for Europe for climate change modelling and impact applications. International Journal of Climatology, 15, 1333-1364.

JÄGER-WALDAU, A., HULD, T., ŠÚRI, M., CEBECAUER, T., DUNLOP, E., OSSENBRINK, H. (2006): Challenges to Realise 1% Electricity from Photovoltaic Solar Systems in the European Union by 2020, 4th World Conference on Photovoltaic Energy Conversion, 7. – 12. 5. 2006, Waikoloa, USA.

JENČO, M. (1992): Distribúcia priameho slnečného žiarenia na georeliéfe a jej modelovanie pomocou komplexného digitálneho modelu reliéfu. Geografický časopis 44: 342-355.

KAŇUK, J. (2007): Analýza solárneho žiarenia pre urbánne územia. Zborník zo VIII. vedeckej konferrencie doktorandov a mladých vedeckých pracovníkov. FPV UKF Nitra, ISBN: 978-80-8094-106-2

KAŇUK, J. (2008): Analýza dostupného globálneho žiarenia v urbánnych územiach Slovenska pomocou GIS. Geografia Cassoviensis, ročník II., 1/2008, Ústav geografie, Prírodovedecká fakulta Univerzity P. J. Šafárika, Košice, str. 59 - 64

KAŇUK, J., ROSIČ, M., HOFIERKA, J. (2008): Mapovanie areálov bytových domov v mestách Slovenskej republiky z aspektu energetického využívania slnečného žiarenia. Submitted to Geografický časopis.

KITTLER, R., MIKLER, J. (1986): Základy využívania slnečného žiarenia. Bratislava, Veda.

KITTLER, R., PULPITLOVÁ, J. (1988): Základy využívania prírodného svetla. Bratislava, Veda.

KRCHO, J. (1990): Morfometrická analýza a digitálne modely georeliéfu. Bratislava, Veda.

LAURMAN, J., A. (1973): Climate change from fossil fuel generated CO_2 and energy policy. Environment International, Volume 2, Issues 4-6, Pages 461 – 473

LITTLEFAIR, P. (2001): Daylight, sunlight, and solar gain in the urban environment. Solar Energy 70, pp. 177-185.

MARKS, A. (1965): Energetika slonečna, Przeglad technicny, Warszawa

MATLOVIČ, R. (2006): Geografia - hľadanie tmelu (K otázkam autonómie a jednoty geografie, jej externej pozície a inštitucionálneho začlenenia so zreteľom na slovenskú situáciu). Acta Facultatis Studiorum humanitatis et Naturae Universitatis Presoviensis, Folia Geographica. 9, s. 6 - 43

MUNEER, T. (2004): Solar Radiation and Daylight Models (with software available from companion web site), Napier University, Edinburgh, Elsevier Butterworth – Heinemann, Oxford, ISBN 0 7506 5974 2, p. 345

MUSELLI, M., NOTTON, G., LOUCHE, A. (1999): Design of Hybrid-Phofovoltaic Power Generator, with Optimalization of Energy Mamagment, *Solar Energy* Vol. 65, No. 3, pp. 143–157

NETELER, M., MITASOVA, H. (2004): Open Source GIS: A GRASS GIS Approach, Kluwer Academic Publishers, Boston

OSTROŽLÍK, M. (2002): Time variability of global solar radiation in high-mountain region. Contributions to Geophysics and Geodesy, 32, 277-290.

PAULOV J. (1998): Niekoľko úvah o geografii na prelome 20. a 21. storočia a 2. a 3. tisícročia. Acta Facultatis Studiorum humanitatis et Naturae Universitatis Presoviensis, Folia Geographica. 2, s. 11 - 22

PEREIRA, F. O. R., SILVA, C. A. N., TURKIENIKZ, B. (2001): A methodology for sunlight urban planning: a computer-based solar and sky vault obstruction analysis. Solar Energy 70, pp. 217-226

POTOCKÝ, P., HOFIERKA, J. (2006): Potenciál využitia obnoviteľných zdrojov energie v regionálnom rozvoji Slovenska. Acta Facultatis Studiorum Humanitatis et Naturae Universitatis Prešoviensis. Prírodné vedy, Folia Geographica 10, pp. 426-432.

QUASCHNING, V. (2003): Technology Fundamentals. The sun as an energy resource. Renewable energy world

ROBINSON, D., STONE, A. (2004): Solar radiation modelling in the urban context. Solar Energy 77, pp. 295–309.

RUŽINSKÝ, M., ŠÁLY, V. (1996): Fotovoltaika na Slovensku, EE (Časopis pre elektrotechniku a energetiku), roč. II, 4. 5, s.36 - 37

RUŽINSKÝ, M., ŠÁLY, V. (2005): Fotovoltika v kontexte vývoja na začiatku 3. tisícročia a SR. Časopis pre elektrotechniku a energetiku, 2, s. 17 – 20.

RYBÁR, P., TAUŠ, P., RYBÁR, R. (2001): Alternatívne zdroje energie I. Slnečná energia. Vysokoškolské učebné texty. Technická univerzita v Košiciach

SCHARMER, K., GREIF, J., (eds) (2000): The European Solar Radiation Atlas. Vol. 2: Database and Exploitation Software. Paris, (es Presses de l'École des Mines).

SMOLA, A. (1980): Využitie slnečnej energie, Elektrotechnická fakulta SVŠT, Bratislava.

SMOLEN, F. (1980) Rozptýlené žiarenie a jeho podiel na globálnom žiarení v Bratislave. Geografický časopis, 32, 300-311.

ŠENITKOVÁ, I.; EŠTOKOVÁ, A. (2002): Zdroje energie a environmentálna záťaž. Acta Montanistica Slovaca Ročník 7, 4, 257-260

ŠÚRI, M. (2006): Slnečná elektrina a perspektívy jej výroby na Slovensku. Život. Prostr., Vol. 40, No. 3, p. 127 – 132, dostupné na internetovej stránke http://sunbird.jrc.it/pvgis/doc/paper/2006-zp03_suri_pv.pdf (navštívené 9.1.2009)

ŠÚRI, M. (2002): Modelovanie a kartografické zobrazovanie globálneho žiarenia. In Feranec, J. Pravda J., eds. Proceeding of the workshop "Aktivity v kartografii 2002", Bratislava (Slovak Cartographic Society and Institute of Geography SAS), 31.10.2002, 126-133.

ŠÚRI, M., JONES, A.R., DUNLOP, E.D. (2002): Mapping the potential of photovoltaic systems in urban areas of Slovakia. In Brebbia, C.A., Martin-Duque, J.F., Wadhwa, L.C. (eds.) The Sustainable City II, Urban Regeneration and Sustainability, WIT press (Southampton). pp. 1007-1016.

ŠÚRI, M., HULD, T.A., DUNLOP, E.D. (2005): PVGIS: a web-based solar radiation database for the calculation of PV potential in Europe. International Journal of Sustainable Energy, 24, 55-67.

ŠÚRI, M., HULD, T. A., DUNLOP, E. D., HOFIERKA, J. (2007): Solar resource modelling for energy applications. In: Peckham R.J., Jordan G. (eds.) Digital Terrain Modelling, Development and Applications in a Policy Support Environment, Series: Lecture Notes in Geoinformation and Cartography, Springer, pp. 259-273.

SZÖLLÖS, J. (1998): Geografická analýza energie a energetiky: teoretická báza a aplikácia na energetický systém Slovenska, Geographia Slovaca; 14, Bratislava, SAV, Geografický ústav.

SZÖLLÖS, J. (2006a): Analýza kontextu regionálneho rozvoja v predtransformačnom období: energetická infraštruktúra. In FALTAN, Ľubomír (editor) - STRBAVA, J. (editor). Regionálna diferenciácia Slovenska v podkladových štúdiách : regionálna diferenciácia, regionálny rozvoj v Slovenskej republike v kontexte integračných dosahov. - Bratislava : Sociologicky ústav SAV, 2006. ISBN 80-855-44-38, s. 451-475.

SZÖLLÖS, J. (2006b): Analýza vývoja energetickej infraštruktúry a dopadov systémových zmien (po roku 1989) na regionálne disponibility: energetická infraštruktúra. In FALTAN, Ľubomír (editor) - STRBAVA, J. (editor). Regionálna diferenciácia Slovenska v podkladových štúdiách : regionálna diferenciácia, regionálny rozvoj v Slovenskej republike v kontexte integračných dosahov. - Bratislava : Sociologicky ústav SAV, 2006. ISBN 80-855-44-38, s. 785-811.

TAUŠ, P., RYBÁR, R., KUDELAS, D., KUZEVIČ, Š., DOMARACKÝ, D. (2005): Potenciál obnoviteľných zdrojov energie na Slovensku z hľadiska výroby elektrickej energie. ATTP journal, 3/2005, 52 – 55 s.

TURRENT, D., BAKER, N. (1983): Solar Thermal Energy in Europe, D. Reidel Publishing Company, London

ZELENKA, A., CZEPLAK, G., D'AGOSTINO, V., JOSEFSON, W., MAXWELL, E., PEREZ, R. (1992): Techniques for Supplementing Solar Radiation Network Data, Technical Report, International Energy Agency, IEA-SHCP-9D-1, Swiss Meteorological Institute, Switzerland.

Nariadenie vlády SR č. 124/2005, ktorým sa ustanovujú pravidlá pre fungovanie trhu s elektrinou

Smernica č. 2001/77/ES o podpore elektrickej energie vyrábanej z obnoviteľných zdrojov energie na vnútornom trhu s elektrickou energiou

Smernica č. 2002/91/ES o energetickej efektívnosti budov

Strategický dokument COM/2007/723 Európsky strategický plán energetickej politiky

Zákon 656/2004 Z.z. o energetike a o zmene niektorých zákonov

www.ozeport.sk (navštívené 9.1.2009)

www.setri.sk (navštívené 9.1.2009)

GEOGRAFIA A ENERGETICKÉ VYUŽITIE SLNEČNÉHO ŽIARENIA

Zhrnutie

Energetické využívanie slnečného žiarenia je v súčasnosti témou, ktorej sa venuje čoraz väčšia pozornosť. Keďže výskum využívania slnečnej energie a jej priamej aplikácie v krajine je značne komplikovaný a má interdisciplinárny charakter, je nevyhnutné, aby jednotlivé vedy participovali a sústreďovali svoju pozornosť práve na tie aspekty výskumu, na ktoré majú orientovanú svoju metodológiu.

Cieľom práce bolo poukázať na prístupy k využívaniu slnečného žiarenia v krajine pre energetické účely, ako aj hľadať možností uplatnenia geografie pri výskume energetického využívania slnečného žiarenia z energetického aspektu.

Podľa prístupu k skúmaniu slnečného žiarenia z aspektu jeho energetického využívania by sme vedné disciplíny mohli začleniť do troch skupín. Prvou skupinou sú prírodné vedy, ktoré sa zaoberajú predovšetkým fyzikálnou podstatou slnečného žiarenia, jeho vznikom, šírením v medziplanetárnom a atmosférickom prostredí, zákonitosťami časovej diferenciácie jeho distribúcie a pod., ako aj matematickým vyjadrením týchto zákonitostí a vzťahov. Osobitú skupinu prírodných vied tvoria geoekológia a environmentalistika.

Druhú skupinu tvoria technické vedy ako informatika, architektúra, stavebníctvo, energetika a elektrotechnika. Tieto vedy sa venujú slnečnému žiareniu z hľadiska energetického režimu budov (architektúra, stavebníctvo), ako aj vývoju technológií schopných čo najefektívnejšie premeniť slnečné žiarenie na vhodnú formu energie a využiť ju (energetika, elektrotechnika). Informatika je veľmi úzko prepojená z geoinformatikou, ktorá využíva GIS na analýzu, modelovanie a vizualizáciu atribútov relevantných pre diskutovanú tému.

Aj spoločenské vedy sa uplatňujú pri energetickom využívaní slnečného žiarenia prostredníctvom ekonómie, marketingu, sociológie, urbanistiky, demografie a práva. Ekonómia analyzuje rentabilnosť a ekonomickú návratnosť inštalovaných systémov, marketing a sociológia sa podieľajú predovšetkým na skúmaní správania sa obyvateľstva a pozitívnej percepcie potenciálnych solárnych aplikácií. Otázky negatívneho vnímania inštalácií môžu v niektorých regiónoch tvoriť až bariéru pre samotnú inštaláciu slnečných systémov (syndróm NIMBY). Oblasť práva napomáha vytvárať priaznivé legislatívne zázemia.

Uplatnenie geografie pri energetickom využívaní slnečného žiarenia sa realizuje predovšetkým vo vytváraní časopriestorových analýz atribútov, od ktorých závisí aplikácia slnečných systémov. Navyše, samotná geografia stojí v prieniku prírodných, technických a spoločenských vied. Jej objekt štúdia je orientovaný komplexne na krajinu vrátane socioekonomických aktivít obyvateľstva, a preto môže využiť celú paletu svojich výskumných metód pri energetickom využívaní slnečného žiarenia a komunikovať s ostatnými vedami participujúcimi na tomto výskume. Geografiu nechápeme ako nadradenú vedu, ale ako jednu z viacerých vyššie uvedených disciplín, ktoré sa podieľajú pri energetickom využívaní slnečného žiarenia.

Tento článok sa snaží hľadať odpovede na otázky, s ktorými sa stretáme na rôznych fórach a teda, akú pozíciu má geografia pri využívaní slnečného žiarenia pre energetické účely.

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