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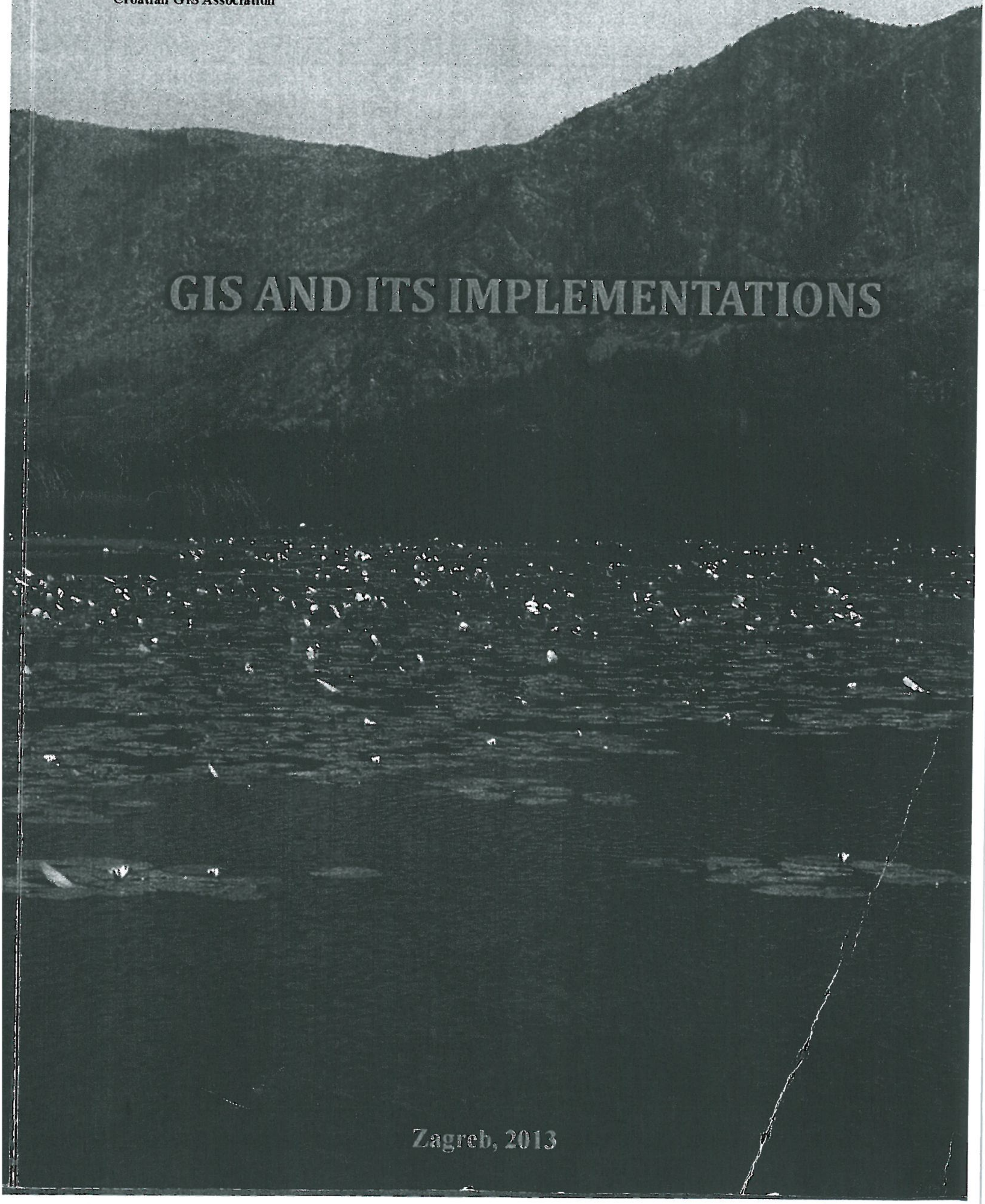

GIS AND ITS IMPLEMENTATIONS

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"GIS and its implementations"

Edited by

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Contents

INTRODUCTION

It all started in the early 1990s. The governing bodies of three biggest Silesian higher education institutions: University of Silesia, Silesian University of Technology and University of Economics in Katowice as well as the Institute for Ecology of Industrial Areas decided to set up a think thank, consisting of both academics and practitioners who were experts on information issues, in order to modernize the infrastructure for spatial information. Thus Silgis Centre was established, its activities included the preparation of conferences of experts working on GIS systems and metainformation.

At that time Polish doctors helping war victims in the Balkan needed some help themselves because their car got damaged. It was dr Davorin Kereković [at that time working on GIS systems in the INA Institute] and his wife Walentyna born in Krakow who offered such help. After coming back to Poland the doctors gave a radio interview in Katowice and the editor of the radio passed the contact details of the Croatian spatial information expert to the Management Board of Silgis Centre. Common interests and openness to co-operation of both parties made their co-operation possible and it started with organizing conferences in Katowice and Szczyrk in 1994. The international conference on "Freedom of information and its limits" in Ustroń in 1997 was attended by 8 Croatian experts. In October 1998 the International Geographic Information Systems Conference and Exhibition "GIS Croatia" was held in Osijek, where to eat dinner by the river Drava we needed to pass by black and white banners warning against mines.

At first sight it seemed that our objectives are different. We wanted to implement principles of gathering and using spatial information for ever-changing geodetic control network of the Silesian industrial lands; on the other hand our Croatian colleagues were focused on using GIS systems for reconstruction (and replacement) of their national heritage destroyed during the terrible war. However, in practice the works of Polish and Croatian experts complemented each other very well, which resulted in common scientific conferences and exhibitions held each year by both countries. Over the years we have also invited experts from England, Germany, Austria, Ukraine, Czech Republic and other countries to work with us.

Traditionally, our annual meetings are held in the most interesting natural and cultural sites of our countries. These meetings enable us to exchange information, find out about new developments and exchange experiences concerning research methods and legal protection of information. While co-operation with some experts is occasional, others have been working with us for many years. Nevertheless, it always results in interesting works, solutions, exhibitions and publications, including in total over 880 articles.

Many things have changed over the years. Silgis Centre was transformed into Silgis Association, some of its members have left while others have joined in. One thing has remained the same – it is the continuous and excellent co-operation with our partners in Croatia. Starting from our first meetings in Silesia and ending with this year twentieth conference, which is to be held in Crikvenica and Krk by Professor Kereković to whom we would like to offer our most sincere thanks for 20 years of educational and organizational co-operation.

Dr Andrzej Michalski

Prof. dr Grażyna Szpor

Regarding hystory of GIS in almost 30 years general conclusions can be that we have deal with powerfull tools gave us lot of research possibilities and satisfaction.All components of GIS have grow up starting with SW and ending with briliant printing HW necessary to ensure high quality graphic output.

In the expert life most atractiv aspect of work with GIS was extremly wide range of aplications.At the beguning defence analyses have turn into sofisticated space analyses,reconstruction aplications,urban planning, natural resource control,protection of natural and cultural heritage and applications in warious sport projects, company and town securyty analyses. Also we note powerfull geomatic demography,natural dissaster analyses and many many other.

From the level of single company to town and regional aspects GIS have been akcepted as everyday option for people needs high quality of data necessary to serch options and make decisions.

Open Europe and World with strong impulse of free market without boundaries needed tools to manage with space unit,land and real estate and modern geomatic,GIS provided all instrument and porocedures ensured modern cartography and cadastre.

Basic positive changes in state services as cadastre and municipal services was awaken with running impresiv analitic solution basewd on informatics and GIS.

Today expert research and achiwements in various branches of life and prouduction give even common citizens chance to use prepeared and opened systems of GIS in everyday life situation.Advertsing,traveling navigation,space information , GPS,GSM and many other options are based on briliant space analyses in GIS environment.

This monograph confirm that expert intuition and spirit research still exsists as a main element of progress in science and practice.

Thats the main reason for us to still be in GIS and belive in future of this beautifull science.

Prof. Ryszard ŹRÓBEK Ph.D. Dsc.
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IDENTIFICATION OF RENEWABLE ENERGY SOURCES IN THE REGION OF WARMIA AND MAZURY WITH THE USE OF *MapInfo PROFESSIONAL SOFTWARE*[7]

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Abstract

RES are sources which use, through the conversion process, wind, geothermal, solar, wave and tidal energy, hydropower, and energy derived from biomass, landfill gas, sewage treatment plant gas and biogases, and from decomposition of stored plant and animal residues. Due to an increased public interest in RES, there is a need to create a map of renewable energy sources divided into particular types of energy sources: wind, solar, geothermal, biomass and biogas.

The paper presents the procedure for RES mapping. With the use of GIS tools, a model map of RES in Warmińsko-Mazurskie province has been created. For detailed analyses, a GIS application was used, namely MapInfo Professional which supports various formats of spatial data, and numerous types of databases. The data imported to the program is displayed as layers composed of a map and tables of attributes. Integration of data originating either from e.g. Microsoft Excel or Access files or database (Oracle, etc.) servers with the map allows visualisation thereof.

In order to create RES maps, results of the survey research conducted in Warmińsko-Mazurskie province as part of the strategic programme "Advanced Technologies for Energy Generation" were also used.

Keywords: MapInfo Professional, energy policy, RES, thematic maps, spatial information infrastructure.

1. Introduction

As follows from the agreed objectives of Poland's energy policy until 2030, the international commitments on the implementation of the EU's climate and energy package compel the diversification of energy generation sources, and a special role in this respect is being attributed to the development of energy generation from renewables. Implementation of that priority will involve supporting projects making use of available local resources of renewable energy sources (RES), including mainly by-products derived from agriculture, and residues from agri-food sector (M.P. [The Polish Monitor] of 2012, item 839). In accordance with Directive 2009/28/EC of the

[7] The strategic program of the National (Polish) Centre for Research and Development (NCBiR): "Advanced Technologies for Energy Generation. Task 4: Elaboration of Integrated Technologies for the Production of Fuels and Energy from Biomass, Agricultural Waste and other Waste Materials."

European Parliament and of the Council on the promotion of the use of energy from renewable sources, energy from RES means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases (Article 2 a of Directive 2009/28/EC of the European Parliament and of the Council.

An increase in the share of renewable energy sources (RES) in the fuel and energy balance may contribute not only to an improvement in the efficiency of the use and saving of the resources of raw materials intended for energy purposes, but also to an improvement in the state of the natural environment. Energy derived from RES is favourable for both the reduction in the volumes of generated waste, and the reduction in pollution of atmosphere and water. Both the energy security and the state of the environment where we live will depend on the shape of energy policy to be taken in the coming years (Gołaszewski, 2012, Namyślak Ł., 2012, p. 285). Pursuant to Directive 2009/28/EC, EU Member States shall gradually increase the share of energy from renewable sources in both the total energy consumption and the transport sector. On the other hand, as follows from Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)[8], RES sources fit into the State's activities and policy affecting the environment. INSPIRE combines elements of spatial information infrastructure being developed in various Member States into one consistent system. The elements of infrastructure include: metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with the Directive concerned. Thematic scope of particular elements is specified in Annexes I, II and III to the Directive. Annex III to the Directive defines energy resources as energy resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource. The Directive in question is aimed at supporting measures concerning Community policies in the field of environmental protection, and policies or measures likely to affect the environment. In particular, those measures refer to the implementation, monitoring of activity, and assessment of strategies being implemented at various levels (from those being implemented at the local level, through the regional and national level, to the European programmes and strategies).

Given the RES development, there is a possibility for setting up a system containing spatial data for renewable energy sources, including the creation of a RES map divided into particular types of energy sources: wind, solar, geothermal, biomass and biogas.

The information on RES sources in Warmińsko-Mazurskie province was obtained from the Energy Regulatory Office (*URE*) and Polish Wind Energy Association (*PSEW*). For the purpose of this study, regional operators involved in production and processing of biomass for energy purposes were also identified. The list of operators (producers and processors of biomass for energy purposes) was compiled on the basis of information obtained from advisors of the Warmińsko-Mazurski Agricultural Advisory Centre (*W-MODR*) in Olsztyn, involved in addressing the issues of the development of energy generation from renewables. In 2012, 123 farmers who declared production of biomass for energy purposes, and 30 entrepreneurs involved in the purchase and processing of biomass for energy purposes, were identified. Finally, after having verified the filled-in questionnaires, information provided by 108 farmers and 27 entrepreneurs was used for creating the map.

The necessary data was collected in both descriptive (tables) and graphical (thematic maps) formats. In order to create thematic maps, the MapInfo Professional application was employed.

2. Energy Generation from Renewable Sources

The development of energy generation from renewable sources is essential for the implementation of key objectives of the national energy policy. Promoting the use of RES allows increasing the degree of diversification of energy supply sources, and creating conditions for the development of distributed energy generation based on the locally available raw materials. The renewable energy infrastructure mainly comprises small generating facilities located in proximity to the customer, which allows enhancing local energy security and decreasing network losses. Energy generation from renewable sources is distinguished by either low or zero pollutant emissions, which ensures positive environmental results. The development of energy generation

[8] INSPIRE is a Directive proposed by the European Commission in June 2004, establishing legal framework for the establishment and operation of an Infrastructure for Spatial Information in Europe.

from renewables also contributes to the development of less-developed regions rich in renewable energy resources (M.P. of 2010, No 2, item 11). Various measures and actions promoting renewable energy have been constantly observed (e.g. heat power engineering – solar panels; wind power – wind farms; cogeneration – biomass production; etc.).

In accordance with the State's energy policy as adopted in 2010, the objectives as regards the development of the RES use are as follows:

- an increase in the share of renewable energy sources in the final energy consumption up to at least 15 % in 2020, and a further increase in that index in the following years;
- achieving, in 2020, the 10 % share of biofuels in the transport fuel market, and an increase in the use of second generation biofuels;
- protection of forests against being over-exploited in order to obtain biomass, and sustainable use of agricultural areas for the purposes of RES, including biofuels, so that competition between renewable energy and agriculture can be prevented, and biodiversity maintained;
- making use, for the purposes of electricity generation, of the existing State-owned damming facilities;
- increasing the degree of diversification of energy supply sources, and creating optimum conditions for the development of distributed energy generation based on the locally available raw materials (M.P. of 2010, No 2, item 11)

The development of renewable energy sources is not only dependent on the dynamic of changes taking place in the field of technology, or the various pressure groups' pressure to reduce emissions of greenhouse gases, but primarily on the possibilities for setting up an integrated system for production of renewable energy sources, processing and distribution of energy, and the on-going quantitative and qualitative monitoring. Achieving the energy policy objectives will require that measures be taken by numerous administrative bodies at government and local level, and by enterprises operating in the fuel and energy sector. In Warmińsko-Mazurskie province, electricity is generated with a share of RES at 23 wind farms, 87 hydroelectric power plants, 2 biomass power plants, and 10 biogas power plants. In the region concerned, there is one operator generating energy from solar radiation, while no power plants employing the co-firing technology are found there (www.ure.gov.pl).

2.1. Wind Farms

Only a couple of years ago, wind farms were rarely seen in Poland's landscape. From the point of view of Poland's reality, large-scale wind farms were a symbol of the economic development of West European countries. Currently, despite both the absence of clear localisation principles and considerable public opposition to carrying out such projects, the development of wind-based energy generation can be observed.

In accordance with Regulation of the Minister of Economy of 4 May 2007 on detailed conditions for the power system operation (Journal of Laws No 93, item 623, as amended), wind farm is a generating facility or a set of such facilities using wind energy for electricity generation, connected to the grid at one connection point. Wind farms may be constructed both onshore and offshore, and both are operated under the same principles. For the farms connected to the Polish National Power System, the converted energy flows to a transformer adjusting the voltage thereof to the value found in the grid, and then, through an appropriate service connection, is supplied to the grid (Stryjecki *et al.*, 2011, p. 20).

2.2. Hydroelectric Power Plants

Pursuant to Article 2(20) of the Energy Law Act, small hydroelectric power plants (SHPP) are classified as renewable energy sources. Small-scale hydropower generation includes hydroelectric power plants with an installed power capacity of up to 5 MW. Electricity is mainly generated in order to meet local needs; however, the mechanical energy of water can also be used for powering a forging shop or sawmill, or for milling grains (Lewandowski, 2001, p. 55). SHPPs are able to make use of the potential of small rivers, agricultural water reservoirs, irrigation, water supply and underground piping systems, and relief channels. Water turbines convert potential energy to kinetic energy which is subsequently converted to electricity in current generators (Tytko, 2008, p. 201). The facilities found in Warmińsko-Mazurskie province are small hydroelectric power plants.

2.3. Biomass

Biomass includes green plants, lignified plants, woodchips, sewage sludge, livestock manure, organic residues from agri-food industry, etc., and is a huge reservoir of energy. Biomass is either burned in household stoves or converted into biofuels or electricity and heat energy in technologically advanced biomass power plants, biogas plants and biorefineries (Lampart, Kowalski, 2010. p. 125).

Biomass means the biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste (Article 2 e of Directive 2009/28/EC of the European Parliament and of the Council). The effective use of biomass in energy generation is favoured by establishing local, scattered energy centres located in rural areas (Gostomczyk, 2009; Jasiulewicz, 2012).

The biomass market in Poland is, in practice, in its formative stage, since it is the forest biomass that has so far been predominant in it. According to Stolarski (2012), in Poland, in 2009, biomass was the largest source for obtaining renewable energy (over 85 %), while in the European Union the share thereof was at a level below 50 %.

In order to satisfy the rural areas' demand for energy, it is recommended to employ, in locations where it is applicable, lower-capacity wind-based and solar energy generation (solar collectors and photovoltaic cells) in addition to biogas plants and cogeneration units (M.P. of 2012, item 839).

2.4. Prosumer (Producer-Consumer) Energy Generation

It may be noted that a dynamic increase has been occurring in the market share of devices for conversion of solar energy. Among those devices, separate groups include devices employing the so-called photovoltaic effect, serving the purpose of electricity generation, and those making use of certain materials' ability for high absorption of solar radiation, and thus for heat generation (Górski, Cenian, 2010, p. 275).

The future of RES development is both the distributed and prosumer (producer-consumer) energy generation. In scattered sources, diverse technologies of electricity and heat generation are employed. These include, *inter alia*, small conventional power plants, coal-firing heat (and power) generating plants, biomass-fired boiler plants, hydroelectric power plants, wind farms, solar power plants, fuel cell stations and energy storage facilities, biogas plants and biorefineries.

Energy generated in the micro- and small-scale scattered energy generation systems is mostly supplied to the local customer. Those devices are used for own use of households, and the operation of corporate, administration and public buildings. Electricity surplus is transferred to secondary distribution networks, while heat surplus is transferred to local heat distribution networks. Manufactured fuels may be used for transport purposes, or provide one of power sources for local fuel networks (Lampart, Kowalski, 2010, p. 123).

3. Geographic Information Systems (GIS)

GIS is a system of software, hardware, data, personnel operating the system and methods for data development, handling, processing and analysing (Głowacki, 2005, p. 10). The main GIS functionalities include acquiring, verifying, collecting, integrating, processing and sharing of spatial data (information on the geographical space).

GIS provides the user with the opportunity to merge descriptive data on objects with information on their spatial location, and also allows thematic mapping, performing spatial analyses, and formulating conclusions.

3.1. MapInfo Professional Software

MapInfo Professional is a product of the MapInfo Corporation company, being one of rather commonly used programs supporting geographic information systems in addition to such packages as ArcGIS, GeoMedia, or Quantum GIS. MapInfo is included in the group of programs described as "desktop GIS". It is distinguished by low system requirements, relative user-friendliness and, at the same time, high level of functionality.

Basic tasks to be accomplished using the MapInfo include:

- creation of spatial databases, management of numerical map layers and tables of descriptive data;
- making use of external sets of data (of various formats and locations) through ODBC import or connection;

- searching for and transforming data using SQL;
- vectorisation and edition of the geometry of object, imaging data input;
- statistical calculations, measurements, calculations of the location, length and surface of objects;
- spatial analyses, determining relationships between objects, and syntheses (e.g. regionalisation);
- geocoding – making use of address information for the localisation of objects and network analyses;
- editing cartographic presentations, general geographical and thematic maps (choropleth maps, diagram maps, dot map, etc.);
- creating, publication and printing reports. (Kowalski, 2005, p. 3)

3.2. Creating a Spatial Database in MapInfo for Identification of RES Sources

Based on the data obtained from the *URE* and *PSEW*, a database of RES power plants in Warmińsko-Mazurskie province was developed. Data from the *URE*, containing the list of RES power plants, was obtained in the tabular format in Microsoft Excel.

Table 1

List of enterprises generating electricity derived from RES in Warmińsko-Mazurskie province

Region	Discrikt	WOA count	WOA power [MW]	WOB count	WOB power [MW]	WOC count [MW]	WOC power [MW]	WIL count	WIL power [MW]	BGO count	BGO power [MW]	BGS count	BGS power [MW]	BGR count	BGR power [MW]	BMG count	BMG power [MW]	BMP count	BMP power [MW]
Warmińsko-Mazurskie	bartoszycki	1	0,12																
Warmińsko-Mazurskie	braniewski	2	0,047	2	1,04	1	2,64												
Warmińsko-Mazurskie	działdowski	3	0,19					1	0,8										
Warmińsko-Mazurskie	elbląski	3	0,124	1	0,48					1	0,4	2	0,712						
Warmińsko-Mazurskie	ełcki	3	0,132					1	0,6	1	0,433								
Warmińsko-Mazurskie	giżycki	2	0,096					1	4,5										
Warmińsko-Mazurskie	gołdapski	6	0,855	1	0,349			7	53,5										
Warmińsko-Mazurskie	iławski	2	0,094					6	69,3	1	0,443								
Warmińsko-Mazurskie	kętrzyński	9	0,934					1	70										
Warmińsko-Mazurskie	lidzbarski	9	0,831	2	1,2	1	1	1	0,075										
Warmińsko-Mazurskie	mrągowski	1	0,044																
Warmińsko-Mazurskie	nidzicki																		
Warmińsko-Mazurskie	nowomiejski	8	0,602					2	1,6					1	1,2				
Warmińsko-Mazurskie	olecki	4	0,152					1	1										
Warmińsko-Mazurskie	olsztyński	18	1,183	1	0,9	1	2,16		/	1	0,702	1	0,802						
Warmińsko-Mazurskie	ostródzki	1	0,115					1	0,1	1	0,438					1	0,22		
Warmińsko-Mazurskie	piski																		
Warmińsko-Mazurskie	szczycieński	2	0,055															1	0,5
Warmińsko-Mazurskie	węgorzewski	1	0,17	1	0,4														
	razem	75	5,744	8	4,369	3	5,8	22	201,475	5	2,416	3	1,514	1	1,2	1	0,22	1	0,5

Source: Energy Regulatory Office (*URE*)

Key to the table:
WOA – hydroelectric power plants with a capacity of up to 0.3 MW
WOB – hydroelectric power plants with a capacity of up to 1 MW
WOC – hydroelectric power plants with a capacity of up to 5 MW
WIL – onshore wind power plants
BGO – sewage treatment plant biogas power plants
BGS – landfill biogas power plants
BGR – agricultural biogas power plants
BMG – biomass power plants firing forest, agricultural, and garden wastes
BMP – biomass power plants firing wood-derivatives and pulp and paper industry production waste

The subsequent activity was the development of the database of RES power plants in the MapInfo Professional application, using the database of communes and districts. For the purpose of the new set (RES database) in the MapInfo, the structure of the table was modified, i.e. expanded with new columns concerning the types of RES power plants (biogas, biomass, geothermal, solar, wind and hydropower plants).

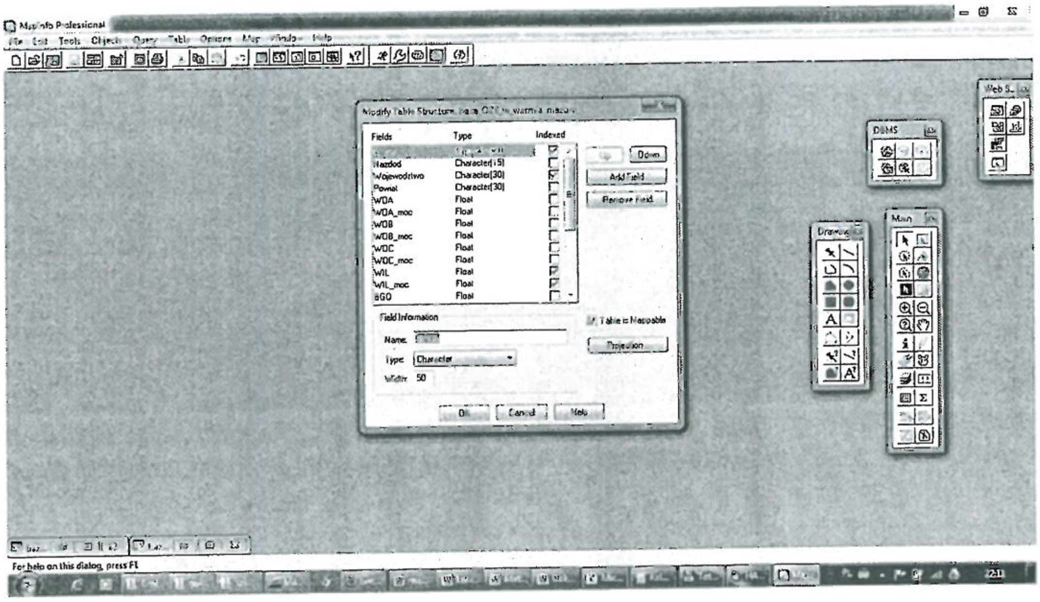

Fig. 1. Screenshot of the MapInfo Professional window – types of data in the set

Source: own work.

In the table window, objects are represented by rows (records), while columns correspond to the object attributes. The attribute values are entered in the table fields according to the type (format) as defined separately for each attribute.

Data input to the MapInfo database depends on the needs and type of source materials. At the next stage of building the RES database, the MapInfo set table was updated using data from the *URE* in the Microsoft Excel format. Data from the Excel spreadsheet application may not be edited in MapInfo. In order to edit, it is necessary to make a copy thereof, and subsequently open it.

Information input to the set may be performed through entering descriptive data in three possible manners in the information window, table, or using update queries. For the development of the RES database, data from the *URE* were introduced to a new database using update queries (Fig. 2).

The combined set (i.e. RES database) was successively enhanced with new map layers in the raster format, e.g. a map of Poland's windiness, a map of the country's insolation, and a vector map of watercourses and water reservoirs located in the region of Warmia and Mazury.

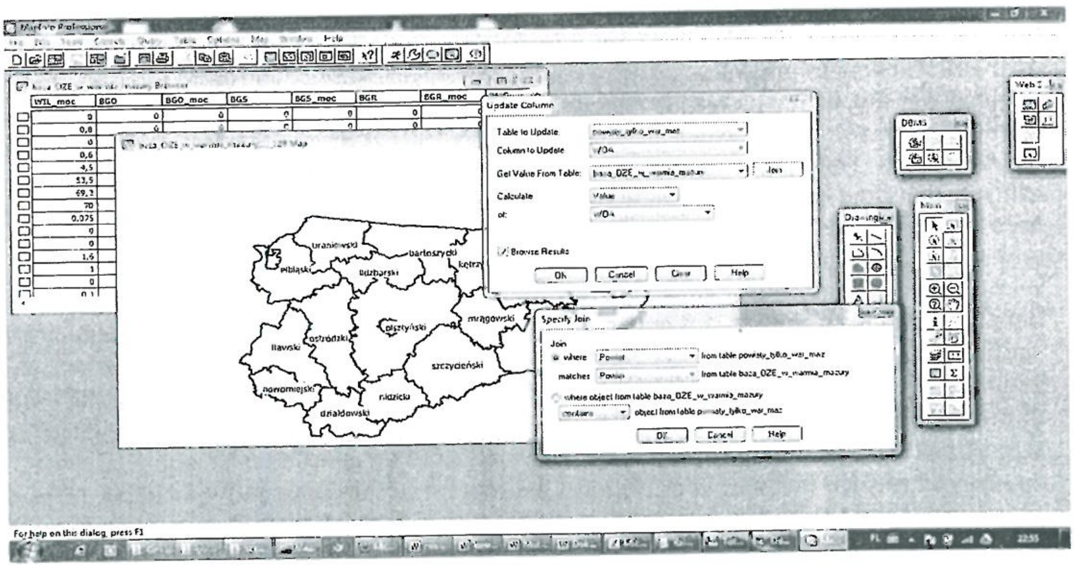

Fig. 2. Screenshot of the MapInfo Professional window – combining databases

Source: own work.

Contents of the set containing spatial objects are displayed as a thematic layer in the map window. Most frequently, the map is a set of multiple layers arranged in an appropriate order; moreover, at a given time, the layer may be visible, editable, and selectable, and may contain auto-labels (Fig. 3).

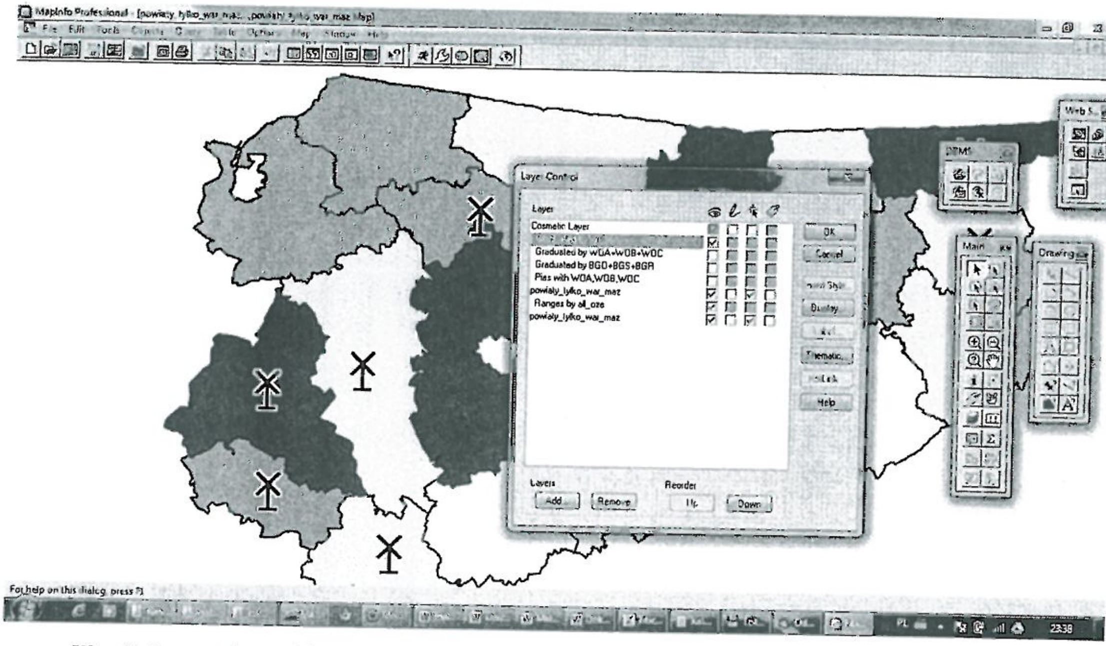

Fig. 3. Screenshot of the MapInfo Professional window – overview of RES database layers

Source: own work.

The presentation of sets in a form of map layers allows both the arbitrary compilation of the presentation contents, and providing it with a graphical format corresponding to the purpose of the map. Spatial data contained in each set may be presented in a graphical format on multiple visualisation layers. By making use of the possibilities provided by the MapInfo Professional application, on the basis of the developed open RES database, numerous spatial analyses were conducted, and the results were presented as thematic maps. This is particularly important for the RES database (dynamic RES development, new RES sources). After having entered the data into the database, the MapInfo Professional application automatically updates the compilations as thematic maps.

3.3. Thematic Maps

The most efficient way to present a given phenomenon in space, and determine the variation of the spatial value, density, or intensity of geographical phenomena, as well as relationships between them, is through thematic maps, which provide the visualisation of specific and socio-economic issues and phenomena. Thematic maps are graphic material supporting decision-making processes of various institutions and organisations implementing socio-economic strategies and programmes. An increased interest in such maps stimulates searching for new contents which they may present.

Thematic maps should provide the following features:

- reasonable selection of contents, and appropriate expression of the level of the contents' detail in relation to the general geographical and topogràphical contents, and elements of special contents;
- maintaining maximum relevance;
- ensuring full fidelity and reliability of the contents, which is conditioned by appropriate selection of supplementary cartographic materials used for creating the map;
- application of such manners for graphical presentation, colouring and publishing form so as to achieve the optimum perceptiveness effect (Przewłocki, 2000).

Thematic maps as created in the MapInfo constitute subsequent layers in the database. These were edited on the basis of spatial objects contained in the newly-created RES database. Descriptive data from multiple tables may be used through SQL queries.

For a given layer, multiple alternative presentations of the same issue may be prepared. A significant feature of thematic overlays is the dynamic refreshing thereof during the edition of attribute values. This allows maintaining the on-going relevance along with the permanent expansion of the RES database.

Based on the created RES database, a thematic map was developed for the generation capacity of RES power plants, presenting, at the same time, the distribution of a given type of RES power plants in Warmińsko-Mazurskie province (Fig. 4).

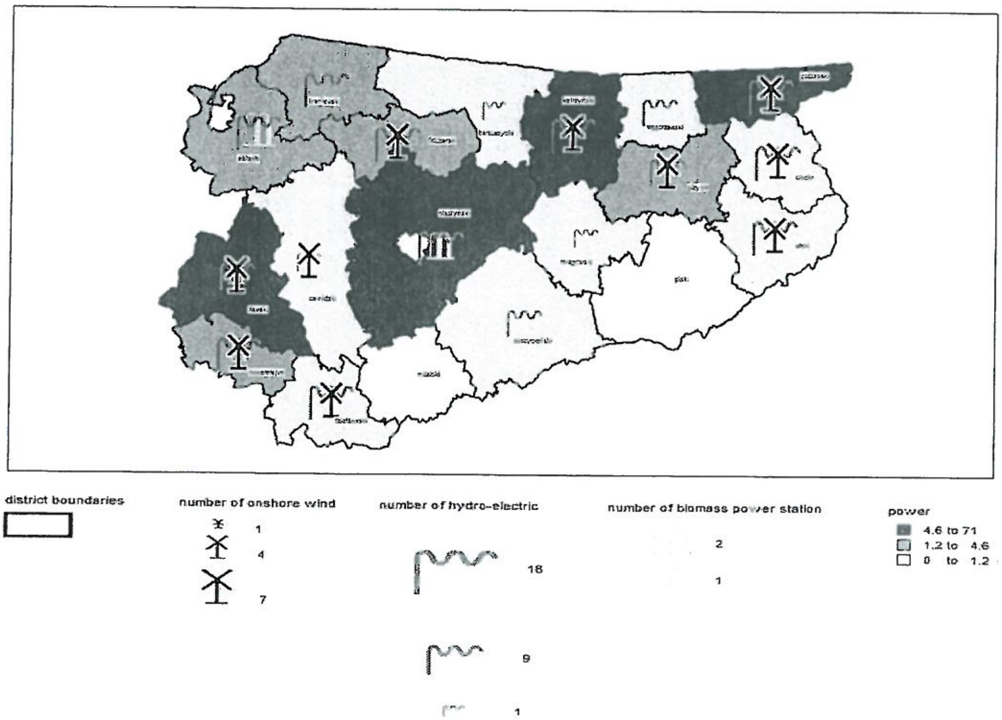

Fig. 4. Map of RES in Warmińsko-Mazurskie province

Source: own work.

As follows from the analyses performed, it is the wind power plants that have the biggest share in the installed generation capacity of RES in the region. Therefore, a thematic map was created, which shows the installed capacity of wind power plants in the districts; moreover, the location of wind power plants is shown (Fig. 5).

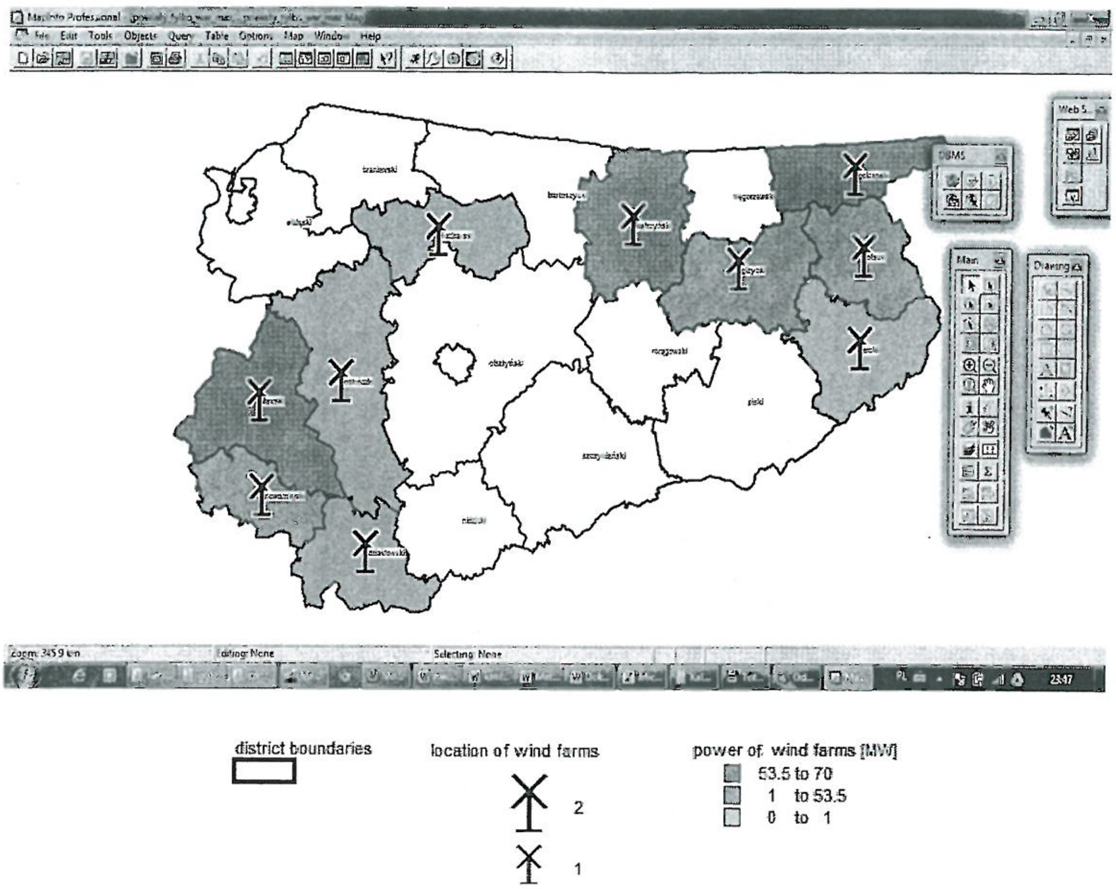

Fig. 5. Map of the wind power plants' capacities in Warmińsko-Mazurskie province

Source: own work.

3.4. Possibilities for Making Use of WMS Servers (geoportal.gov.pl) in the MapInfo Program

MapInfo Professional provides functions which allow connecting with the WMS (Web Map Services) and WFS (Web Feature Services) services. Thanks to these options of the program, it is possible to e.g. make use of the resources of Polish Geoportal, and show, against the background of the protected areas in the province, the detailed location of particular wind power plants. Based on the detailed location of wind turbines, established with the use of geocoding[9] function (Fig. 6), it may be concluded that wind farms are located outside the protected areas. Another manner for the presentation of RES may be the visualisation against an orthoimage.

[9] Geocoding is determining the location of geographical objects in relation to the adopted co-ordinate system; most frequently, it is the process of assigning a postal address to a pair of co-ordinates (as cited in: J. Gaździcki's Internet Geomatic Lexicon (*Internetowy Leksykon Geomatyczny*).

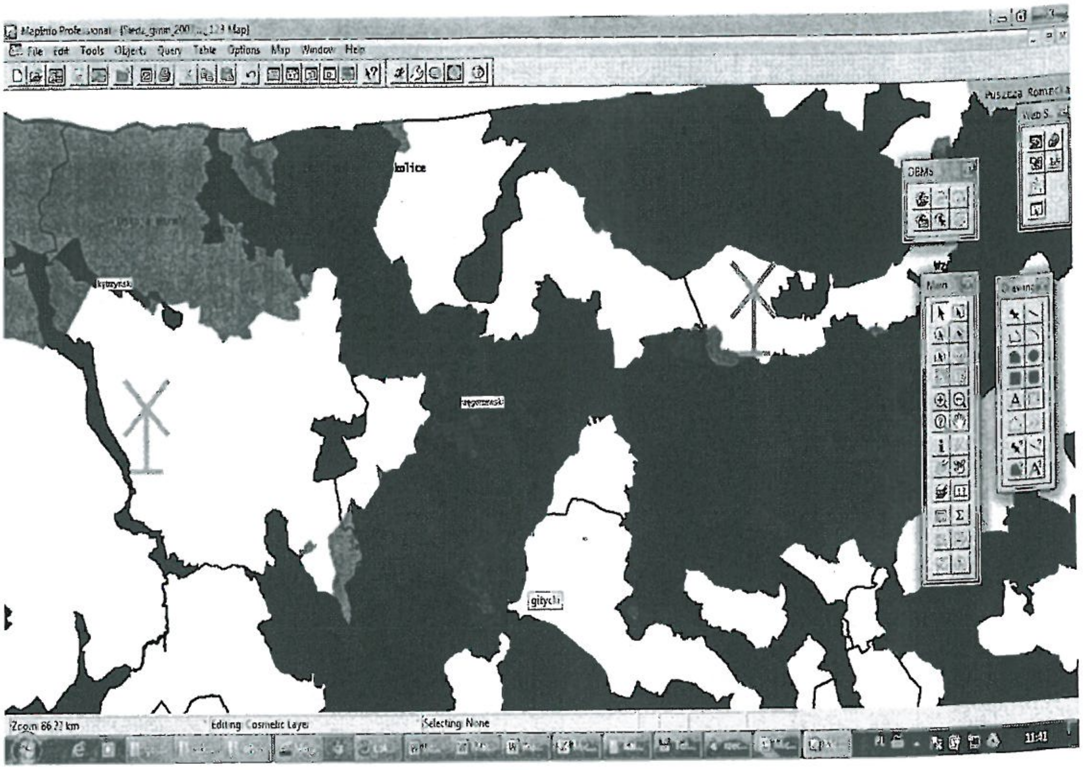

Fig. 6. Thematic map showing the detailed location of a selected wind farm against the background of protected areas

Source: own work.

Advantages of GIS systems include: openness, mobility and the possibility for constant expansion and updating. An example of such use is a thematic map of the location of producers and processors of biomass for energy purposes in Warmińsko-Mazurskie province. For the purposes of this study, results of the field research on the location of producers and processors of biomass in the region were used. In order to enter operators associated with the use of biomass for energy purposes in the database, the geocoding function of the MapInfo Professional application was applied; in this case, the location coordinates were determined on the basis of geographical names of places (Fig. 7).

As can be seen, the location of operators being the potential receivers of raw materials favours the concentration of field biomass production for energy purposes. In the central part of the region, single operators are found, while in the northern and south-eastern belts there are few receivers and producers of biomass (Fig. 7). The location of operators and holdings associated with production of biomass for energy purposes may be used for the optimum use of raw material resources (taking account of the rationality of production depending on e.g. the distance to the market outlet). In connection with the EU energy policy, it is possible to use the tool concerned as an instrument supporting the management of socio-economic development at the local level.

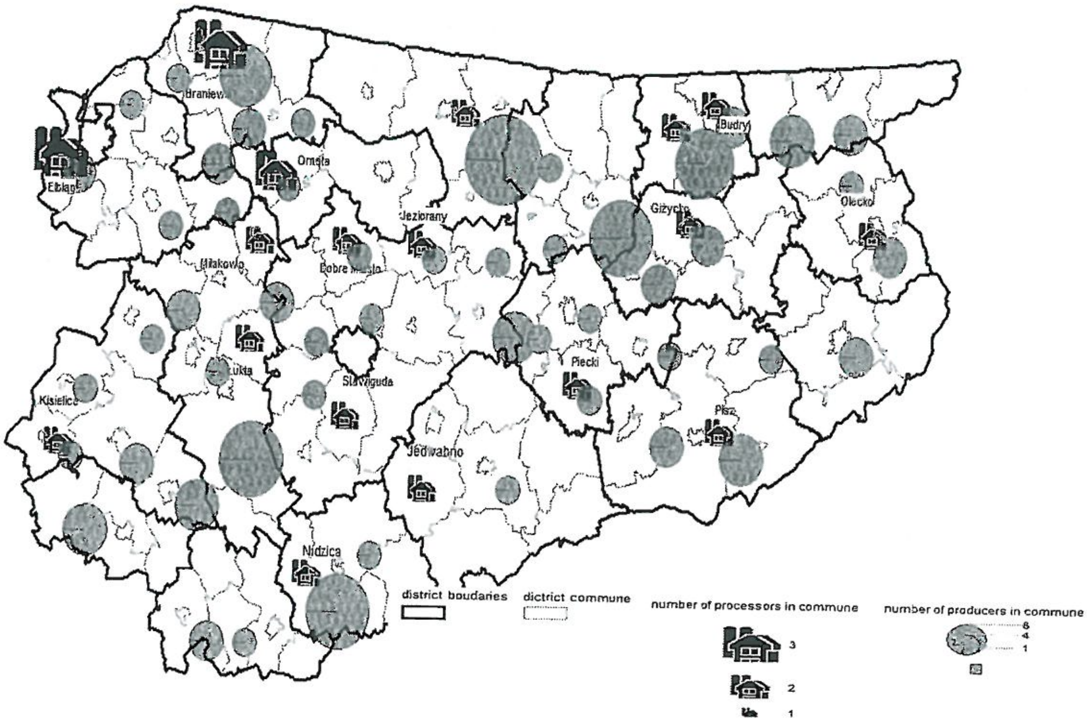

Fig. 7. Distribution of biomass producers and processors in Warmińsko-Mazurskie province.

Source: own work based on survey.

A useful tool which allows searching for the optimum location of producers in relation to the operators involved in the purchase and processing of biomass for energy purposes is the buffer function of the MapInfo Professional application, which allows, in line with the imposed criteria, generating a map of the range; in this case, a radius of 30 km was adopted (Fig. 8).

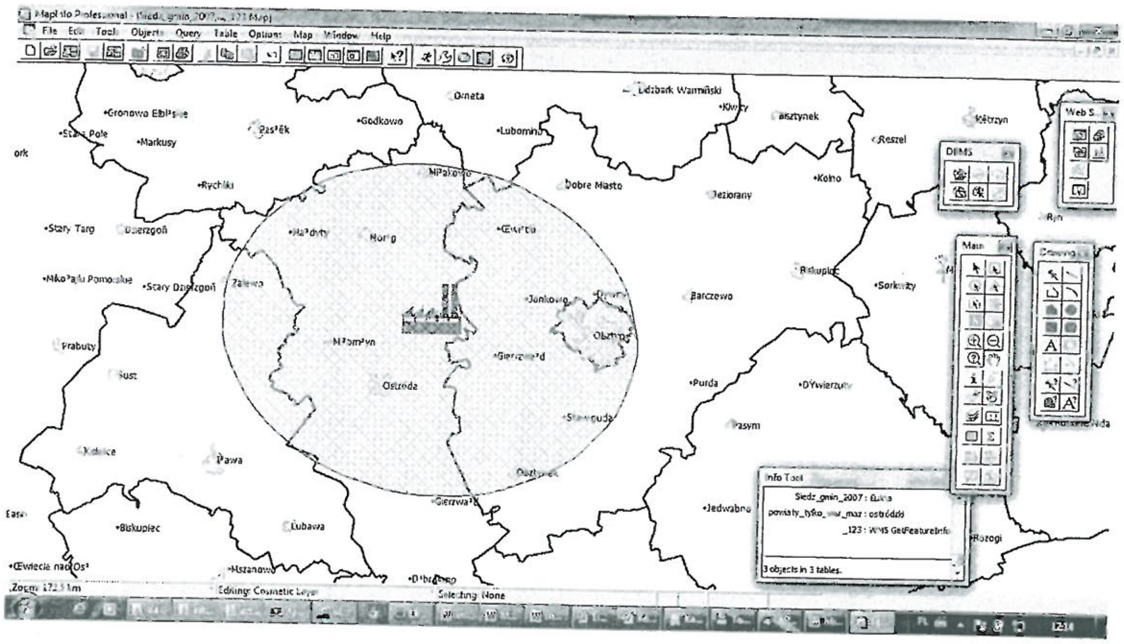

Fig. 8. Indication of the area of potential biomass suppliers to the processor in the village of Łukta

Source: own work.

4. Conclusions

The possibilities provided by GIS allow the on-going monitoring of the stage of RES development at the local, regional and national level. The tool concerned provides a possibility for recording small, scattered RES sources (places of production of vegetal and animal biomass, location of wind farms, hydroelectric power plants, or photovoltaic panels). GIS may be used for the visualisation of new socio-economic problems and phenomena. Limitations to the popularisation of the tool in question include the users' skills, and access to information. GIS systems allow collecting spatial and descriptive data, arranging it in a logical structure, verification, integration, and comprehensive analysis and visualisation.

GIS primarily allows performing complex spatial analyses, and creating diverse models of phenomena and simulations of processes occurring in the environment. The input data to the GIS system usually constitutes source information in a form of maps covering various themes, remote sensing images, results of direct land survey, and other types of information in numerical and text formats. Results of the analyses, simulations and modelling performed with the use of the tool in question, or queries sent to the database, may be presented in a form of maps, graphs or tables. GIS system is distinguished by openness, mobility and the possibility for constant expansion and updating, which will certainly facilitate the monitoring of the RES sector development, not only at the local but also at the regional, national or global level.

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