Sustainable Energy Management of the Residential Area Scharnhauser Park by 2D GIS

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SUMMARY

The main objectives of the described research work are the analysis of the potential of solar energy in urban areas, visualization of results from the energy management system and its publication via Internet. The project is embedded in an international research project of the European Union called POLYCITY. Test area is the residential area Scharnhauser Park close to Stuttgart.
Using the program GeoMedia Professional, a GeoWorkspace (GWS) for the residential area of Scharnhauser Park has been populated with all available data for the analyzed residential area. In addition, the tool GeoMedia Grid has been used to analyze the solar potential of roofs for the installation of PV-Systems. Within the program GeoMedia WebMap Publisher an appropriate user interface for publishing the energy data of Scharnhauser Park has been built. During this research work, the products of the GeoMedia family have proved as easy to use tools for analyzing and publishing the energy data.
Publishing data via Internet have given customers a possibility to check their energy consumption values as well as the PV-potential of their roofs. The developed system could be seen as an example of a universal documentation tool for all, who are interested in energy monitoring systems for residential areas like Scharnhauser Park.

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1. INTRODUCTION

The presented research work is embedded in an international research project co-funded by the European Commission called POLYCITY, which is coordinated by the Stuttgart University of Applied Sciences. The German test area is the residential area Scharnhauser Park close to Stuttgart, which is the largest development area of the Stuttgart Region and has been developed after the American military forces, had left the area in 1992. The test area Scharnhauser Park represents an exemplary ecological community development with low energy buildings and a wood fired ORC co-generation plant, which generates approximately 50% of electricity and 80% of heating energy for the researched area. The main aim of this project is to encourage other municipalities to realize similar projects and to show them how to facilitate the penetration of sustainable energy concepts and energy systems.

The research work described in this publication demonstrates the applicability of GIS-technology for improving the energy management of the analyzed area. In order to achieve this, the energy related data of Scharnhauser Park was collected, analyzed, visualized and published via internet application. This application shall contribute to the improvement of sustainable urban development.

2. METHODOLOGY OF THE RESEARCH WORK

2.1 **Data acquisition**

2.1.1 Energy consumption data

The energy consumption data of all buildings within the analyzed area Scharnhauser Park originate from the archive of the municipal utility company Esslingen am Neckar GmbH. The data sets contain annual heat and electricity consumption data for each building in form of Excel or paper sheets. The so collected data together with the building attributes (e.g. address, type of building, heating areas), which originate from the archive building plans, were stored in a database. In order to organize the above mentioned data, a data model was developed and implemented in Access.

2.1.2 Laser scanner data

The laser scanner data originates from the Land Survey Office Baden-Württemberg (LV-BW). These data are data points with a density of 4 points per square meter and are divided in ground and vegetation points. These data points are delivered in form of an ASCII-file, like it is shown in the next picture:

3519022.85	5397002.97	312.18
3519046.79	5397002.64	309.09
3519060.79	5397002.39	308.89
3519018.01	5397004.26	316.83
3519024.38	5397003.64	310.47
(…)		

Figure 1: ASCII-file with the coordinates and high value of the data points

2.1.3 Spatial data

The project POLYCITY was provided with a map of Scharnhauser Park from the city of Ostfildern. This map is a DXF - file and contains all dimensions and object information for the analyzed area, like for example building construction, building name, house number, street name.

2.2 Data analysis by using GIS technology

"The potential of GIS to provide consistent, quantitative information in an accessible format has it well-placed to be a key tool in evidence based sustainable development policy-making." [Best practice]. "To find the processes of spatial distributions, many researchers in urban analysis are often required to manipulate a large amount spatial data about urban areas" [Okunuki, 2000]. In order to be able to display the data of the analyzed area in a clear and understandable manner, the products of GeoMedia family were used.

2.2.1 GeoMedia – Products

GeoMedia Professional has the capability to directly access spatial data in different vendor formats and immediately use it by visualizing and analysing it. GeoMedia Grid gives a possibility to integrate the vector and grid data formats for viewing and analysis. GeoMedia Web Map Professional enables to build a geospatial Web application, which provides access to geospatial data.

2.2.2 Using GeoMedia-Products in the project POLYCITY

The next picture presents the workflow for collecting, analyzing, visualizing and publishing of all project related data.

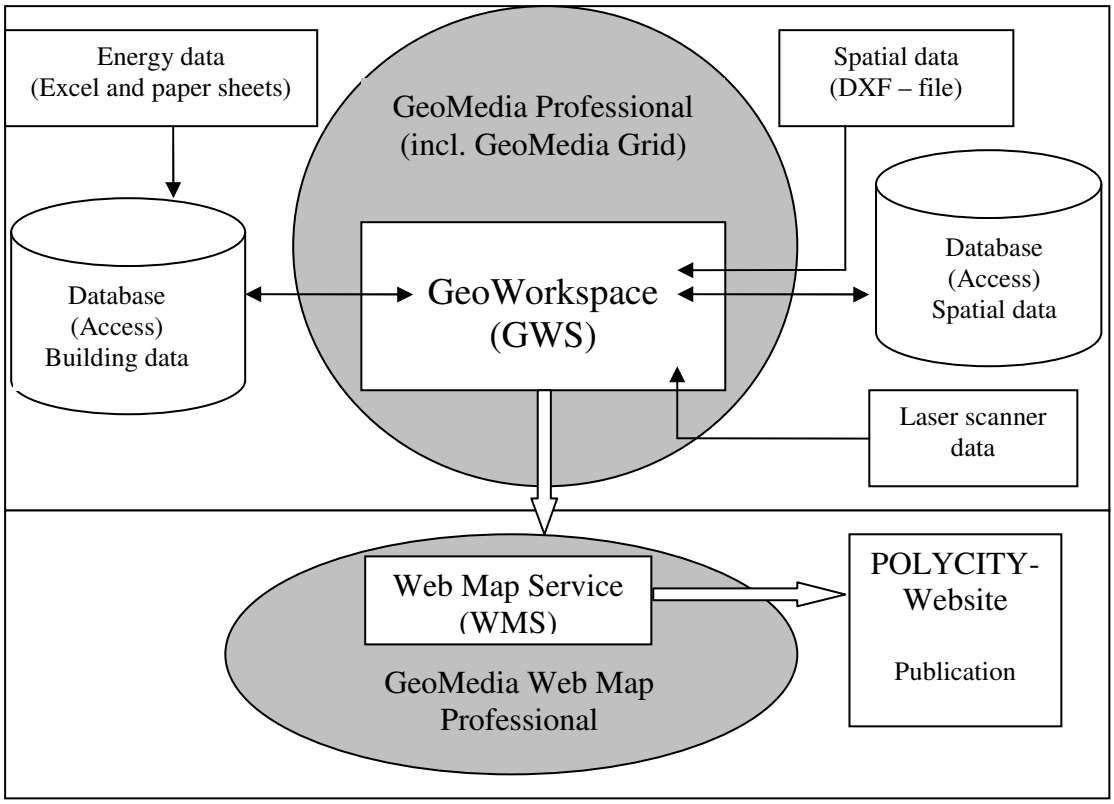

Diagram 1: Scheme of using GIS technology for analysis of the project related data

The collected non-spatial attribute and energy consumption data were modelled and stored in an Access database (see 2.1.1). Within the program GeoMedia Professional the spatial data from the DXF-file was visualised in a GeoWorkspace where they were automatically transferred into a new Access database. After this the program GeoMedia Professional was used to join the spatial data with the energy consumption data by the building ID. Within the GeoWorkspace the energy consumption data was visualised in a number of thematic maps, where the colour intensity indicates the degree of energy consumption (Figure 2).

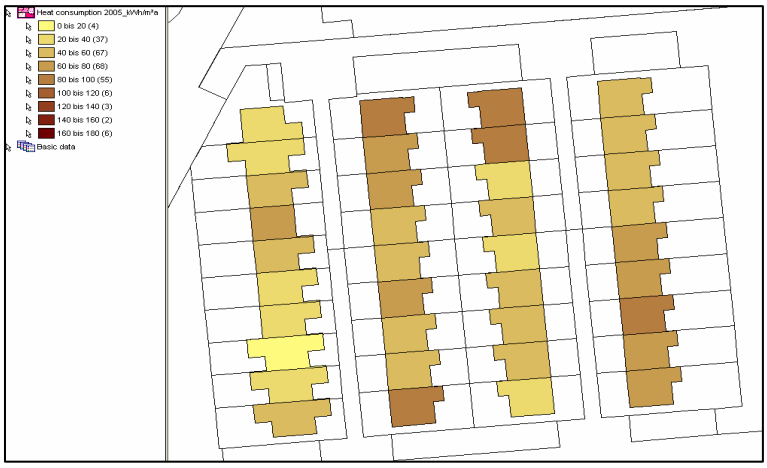

Figure 2: Thematic map of the annual heat consumption 2005

Further on, the program GeoMedia WebMap Publisher was applied for publishing the thematic maps about energy consumption in the Internet via Web Map Server (WMS) incl. an appropriate user interface.

GIS is used for identifying and quantifying the effect of local constraints on the renewable energy potential [Ramachandra, 2006]. Regarding it, the tool GeoMedia Grid was used to analyze the solar potential of roofs for the installation of PV-Systems, which was calculated on the basis of airborne laser scanner data combined with existing building contours. "PV potential use is based on estimates of practical areas for collection use (building roof areas, suitably inclined and oriented surfaces) combined with land use data (important for central receiver fields)" [Sörensen, 2001].

Finally, the built WMS was implemented in the POLYCITY-Website to publish all the available data via Internet.

3. EVALUATION OF THE RESULTS

3.1 Analysis of the energy consumption data

The analysis of the energy consumption data showed possible savings in the energy consumption of the buildings. The visualisation and interpretation of the energy consumption data in the GeoWorkspace showed not only relatively high energy consumption data but also significant differences between the values of the energy consumption of buildings within one building type (standard deviation of the average value up to 40% for building type J). This shows that the user interaction has an enormous impact on the energy consumption and gives possibilities to reduce it by changing the user's behaviour. The next picture shows the typification of some one-family houses in the analyzed residential area:

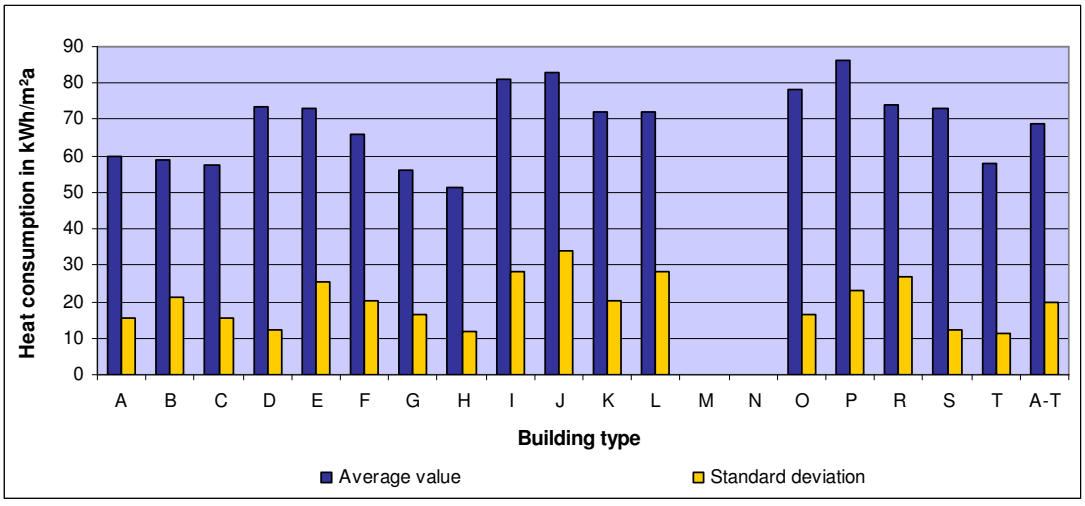

Figure 3: Average values for the annul heat consumption 2006 of different building types

3.2 Solar roof potential analysis

The analysis of the solar roof potential showed a great photovoltaic potential. Due to the fact that 80% of the roofs in Scharnhauser Park are flat roofs, there is a significant solar roof potential for the installation of the PV-systems. Despite the fact that some of the roofs are not suitable for the PV-installation because of the constructional systems like chimneys, windows and dormer windows almost half of the total roof area of the Scharnhauser Park (98.000 m²) can be used as the PV-potential. Using the data from the roof potential analysis and the average annual electricity consumption data it was possible to calculate the solar fraction by considering the relation between the PV energy production and the measured electricity consumption. The first general calculation gave, that 40% of the electricity consumption of Scharnhauser Park could be covered by the solar energy from the PV-systems, like it is shown in the following Diagram 2.

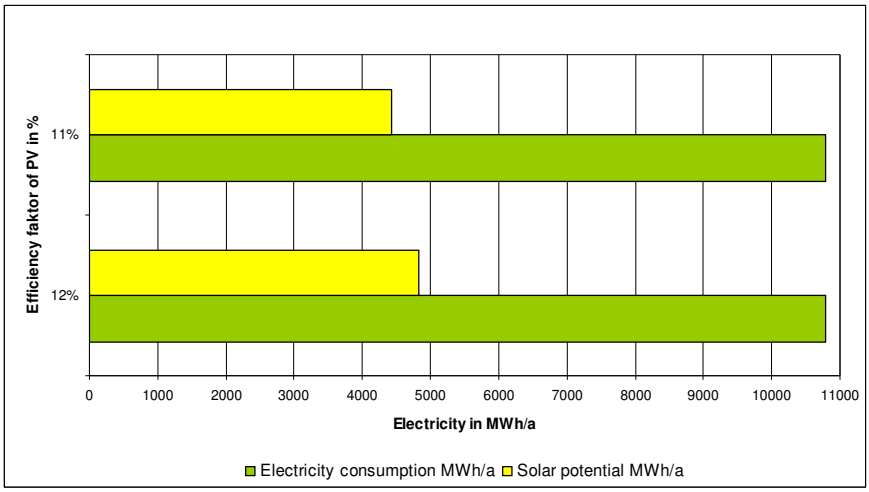

Diagram 2: Solar roof potential of the residential area Scharnhauser Park for two different photovoltaic system efficiencies. The electricity consumption data was from 2005.

3.3 Pilot application

With the rapid expansion and development of Internet and WWW (Word Wide Web), Web GIS (Web Geographical Information System) is becoming ever more popular and as a result numerous sites have added GIS capability on their Web sites [Kou-gen, 2000].

After the implementation of the developed WMS interface into the Website of the project POLYCITY, users can have a possibility to access this web portal in order to evaluate the status of their energy consumption. Regarding the personal data safety, only the average annual energy consumption values of each of the buildings types are visualized. The data for the solar potential of the roofs can be also accessed via the WMS interface.

The next figure shows the solar areas of the building roofs. Here the process which is called overlay gives a possibility to view it together with the aero photo of the whole area (Figure 4).

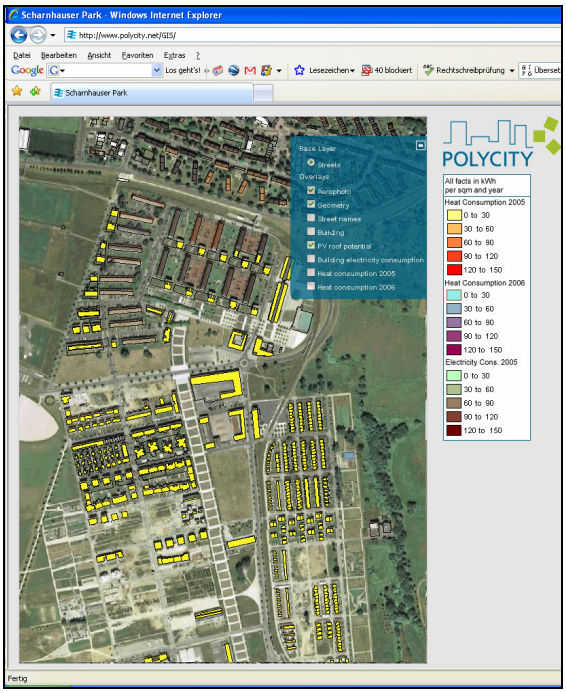

Figure 4: POLYCITY- Web GIS Application (Solar roof areas together with the aero photo of the Scharnhauser Park)

Such type of information dissemination should lead to an increasing awareness among the residents of the project area with respect to their heat and electricity consumption. Those who are concerned with GIS usually say: "Do not end GIS as a boom, but root GIS in society" [Kohsaka, 2000].

4. CONCLUSIONS

The research work described in this publication and carried out within the EU-project POLYCITY is an example for using Spatial Information for sustainable management and modernisation of urban areas. This analysis was mostly based on the energy consumption data of all buildings in the residential area Scharnhauser Park. The results showed a high potential for reducing the energy consumption of the buildings and therefore reducing the CO_2-emissions. Furthermore, the solar roof potential analysis based on the laser scanner data of the analyzed area has been done. This analysis showed significant potential for installation of the PV-systems on the roofs of the Scharnhauser Park. The first general calculation showed that almost 40 % of the electricity consumption of the analyzed area could be covered by the PV-systems. Additionally, the developed GIS-Application has been implemented in the POLYCITY-Website, which gave all users a possibility to show the energy information of their buildings.

The in this paper presented concept of web-based GIS-Application can serve as a model for other communities to support sustainable energy management. However, in this GIS-Application the utilization of spatial data for the preparation for environmental studies has not

reached its full potential. In our opinion, the use of spatial data for the visualization (Energy Management) as well as for analysis (PV-Potential) of the correlations is very useful. The optimization of this system could be achieved by the development of a possibility for a direct access to the appropriate data in distributed network which means the use of Spatial Data Infrastructure (SDI). The basic technology for such data interaction is already available and was used in the described research work.

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BIOGRAPHICAL NOTES

Aneta Strzalka (*1979) graduated the Master Course "Sustainable Energy Competence" in April 2005 from the University of Applied Sciences in Stuttgart. Since than, she has worked as a researcher for building physics at the same institution and has carried out several national and European research projects on sustainable buildings, energy management concepts for communities by using Geographic Information Systems. Since 2005 Aneta Strzalka is working on the large integrated project POLYCITY, which deals with communal energy management implementation and involves 18 European partners and various observer communities. Since 2006 Aneta Strzalka is also a PhD-Student in the Faculty of Mechanical Engineering at Opole University of Technology.

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