Preface

Power supply is one of the most important factors for living standards, human evolution, and socioeconomic development. But during the last few decades, the increasing need for new energy sources has led to a rapidly growing awareness in the field of environmental protection, with focuses on overexploitation and environmental pollution. In order to provide sustainable development, detailed knowledge and quantitative characterizations of our energy sources, distributions of energy and power supply are needed for prediction at local and global scales in time and space.

Assessment of energy sources and power supply optimization can improve situations. Using new methods based on Geographic Information Systems (GISs) enables more complex analyses dealing with spatial and temporal phenomena. Computer analysis and modeling will provide better deployment of existing power sources in order to reduce the operational and maintenance costs of the energy generation units.

This new and important book gathers the latest research in the field and related topics such as the outlook of energy sources and power supplies, key environmental issues, mapping of energy from fossil fuels, optimization of using renewable energy sources, and optimized deployment of existing power sources and renewable energy sources. Chapters are complemented by case-oriented studies that show practical applications.

The first chapter provides an introduction to the assessment of energy sources in the spatial and time scales of the universe, our solar system, Earth, continents and their regions, and mankind. It also introduces basic laws, principles, and physical units. The environmental issues are discussed from a view point of energy consumption by types and regions. The case studies deal with the presentation of spatial data using extensions of spreadsheets such as 3D Maps, development kits for data visualization on websites, and statistical programs.

The second chapter focuses on the introduction of spatial and temporal analyses using the Geographic Information System (GIS). It explains spatial data models in GIS, which are helpful for the assessment of energy sources. The description contains a number of examples to demonstrate GIS functionality. Desktop GISs and other related information systems give an overview of available software tools for

issues described in the next chapters. The case studies show web-based applications for spatial analysis of energy sources, GIS projects, and modeling tools for prediction of air pollution.

The third chapter focuses on energy outlook using data presented by a number of national and multinational agencies and companies, such as the US Energy Information Administration (EIA), the International Energy Agency (IEA), European Environmental Agency (EEA), British Petroleum (BP), and a number of others. Energy production, redistribution, and consumption are illustrated by Sankey diagrams complemented by a number of other charts. Also, various scenarios are discussed in order to decrease global emissions and total cumulative emissions of carbon dioxide. The case studies show spatial data management and datasets related to energy consumption.

The fourth chapter describes energy sources based on fossil fuels. It contains a number of tables and graphs that show global and regional trends of consumption. Mapping of fossil sources is provided by GIS datasets extended with data from GPS and remote sensing. The chapter includes an exploration of environmental effects related to fossil fuel use. The case studies are focused on using GPS and mobile GIS for mapping fossil fuels at a local scale and mapping surface coal mines at a regional scale with satellite images.

The fifth chapter contains information about using hydropower at the global and local scales. It explains types of hydropower sources and provides an overview of existing installations, as well as explores environmental effects of operational hydropower plants. The chapter also introduces hydrological modeling focused on nutrient flows in the basin. The case studies are focused on mapping the largest hydropower plants with data from remote sensing and mapping potential sources for small hydropower plants at the local scale.

The sixth chapter deals with wind power. It explains the basic principles and shows various types of hydropower installations. The wind power sources are explored by mapping wind speed at global and local scales. Thematic mapping contains installed capacity and production of wind power for leading countries. The GIS utilization is provided for risk assessment of wind turbines and wind farms projects. The case studies show data processing related to wind power sources in GIS and mapping potential sources for wind turbines at a local scale.

The seventh chapter shows estimates of solar energy potential and discusses environmental issues. It explains the modeling of solar irradiation with data from ground sensors and satellite systems. GIS is used for the exploration of potential solar sources with the regional and country maps, which can be used for the assessment of electricity generation from photovoltaic and thermal systems in Europe, Africa, and Southwest Asia. The studies are focused on estimates of solar energy by GIS advanced functionality including ArcGIS. Methods for area solar radiation and point solar radiation are tested at the local scale of urban environments.

The eighth chapter describes the assessment of bioenergy potential in the context of existing energy systems. The description is focused on modern solid biomass heating systems, liquid biofuels, and biogas systems. Flow diagrams show global bioenergy flows and provide an overview of different renewable energy sources, and

main technologies to convert them into direct heat, or heat and power. The attached case studies demonstrate spatial data processing related to mapping of potential bioenergy sources and optimization of transport management.

The ninth chapter deals with nuclear power, provides its historical overview, and discusses environmental issues. It also compares nuclear fission and fusion, which represents a great challenge for research and development. The chapter also includes mapping of world uranium mining production, which is documented with a number of thematic maps and charts. An overview of nuclear reactor generations with their deployment is illustrated in diagrams and tables. Environmental effects of using nuclear energy are discussed and complemented by flow diagrams for power generation by fuel and demand by sector for selected regions. The case studies provide mapping of global and regional environmental impacts of operational nuclear installations in relation to population density.

The tenth chapter is principally devoted to the energy storage systems, which are increasingly important for the integration of variable power from renewables in the electricity grid. In particular, pumped storage hydropower and compressed air energy storage systems are explored together with their environmental impacts. The case studies are focused on selected installations of energy storage systems and their environmental evaluation. GIS is used for risk assessment mapping of related ecologies and natural systems, physical environments, and human impacts.

This book is the successor to earlier research activities on environmental consequences of energy use and many years of teaching, as well as research and teaching in the field of GIS and remote sensing. The book incorporates much information from recent reports, papers, and books, which summarize new developments in the assessment of energy sources and GIS. The materials are presented in such a way that they can be understood on different levels, in order to enable students and professionals to make quantitative estimates and form sound judgments. Case studies of energy projects taken from around the world provide examples of using GIS in selected stages of decision-making processes.

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http://www.springer.com/978-3-319-52693-5

Assessment of Energy Sources Using GIS

Matejicek, L.
2017, XIV, 327 p. 314 illus., 296 illus. in color.,
Hardcover
ISBN: 978-3-319-52693-5