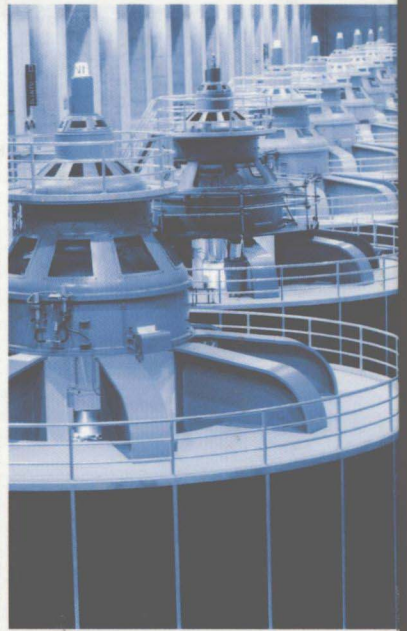
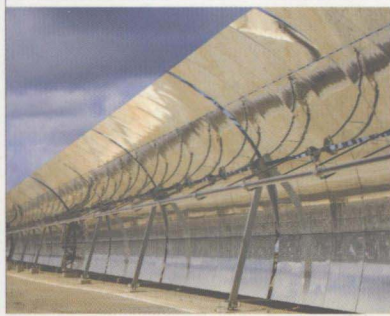
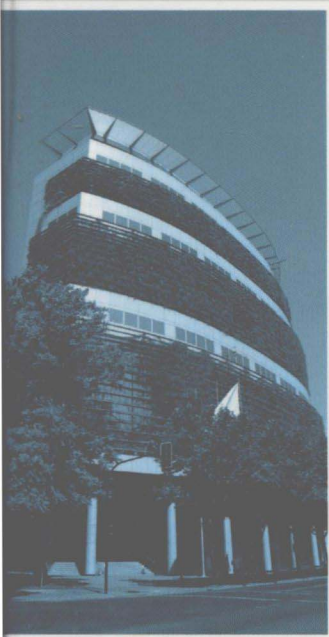


Sustainable Energy Management



Mirjana Golušin | Siniša Dodić | Stevan Popov

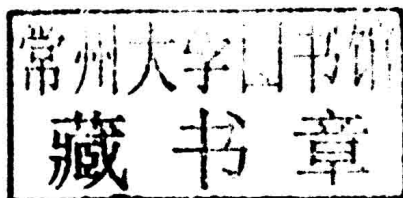


Sustainable Energy Management

Mirjana Golušin

Siniša Dodić

Stevan Popov



ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Academic Press is an Imprint of Elsevier



Academic Press is an imprint of Elsevier
225 Wyman Street, Waltham, MA 02451, USA
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK

© 2013 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data

Golušin, Mirjana.

Sustainable energy management / Mirjana Golušin, Stevan Popov, Siniša Dodić.
pages cm

Includes bibliographical references.

ISBN 978-0-12-415978-5 (hardback)

1. Energy development. 2. Renewable energy sources. 3. Sustainable engineering. I. Popov, Stevan. II. Dodić, Sinasa. III. Title.

TJ163.2.G657 2013

333.79'4—dc23

2012026621

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

For information on all Academic Press publications visit our website at <http://store.elsevier.com>

Printed in the United States of America
13 14 15 16 9 8 7 6 5 4 3 2 1

Working together to grow
libraries in developing countries

www.elsevier.com | www.bookaid.org | www.sabre.org

ELSEVIER

BOOK AID
International

Sabre Foundation

Sustainable Energy Management

Acknowledgments

This book is part of the following five projects: 1) Project No. III 47 009 – *European integrations and social and economic changes in Serbian economy on the way to the EU*, which is supported by the Ministry of Science and Technological Development of Serbia in the period 2011-2014. 2) Project No. 179015 – *Challenges and prospects of structural changes in Serbia: strategic directions for economic development and harmonization with EU requirements*, which is supported by the Ministry of Science and Technological Development of Serbia in the period 2011-2014. 3) Project No. TR-31002 – *Development of bioethanol production from products of sugar beet processing*, which is supported by the Ministry of Science and Technological Development of Serbia. 4) Project No. 114/451-2089/2011 – *Development of bioethanol production on small farms*, which is supported by the Provincial Secretariat of Science and Technological Development of Voivodina. 5) EUREKA project No E15832 – *Development of technology for efficient and economical production of bioethanol fuel at small farms*, which is supported by the Ministry of Science and Technological Development of Serbia.

This book was translated by Mrs. Sanela Šipragić Đokić.



Contents

Acknowledgments	ix
1. Introduction	1
2. Energy and Sustainable Development	
2.1 Definition of sustainable development	7
2.2 Sustainable development principles	11
2.3 Energy sustainability as criteria for development	13
2.4 Dimensions of energy sustainability	16
2.5 Basic concept of energy sustainability	18
2.6 Basic problems of future energy development	21
2.7 Legislation	24
2.8 Case study – European Union	27
3. Energy Management – Planning	
3.1 Traditional concept of energy management	59
3.2 Sustainable approach to energy management	67
3.3 Strategic analysis of energy sector	76
3.4 Strategic objectives of sustainable energy management	78
3.5 Case study – India	81
4. Energy Management – Implementation	
4.1 Development of strategy of sustainable management of energy	103
4.2 Traditional approaches to implementation of sustainable energy management	108
4.3 Creation of organizational structure and corporate culture	113
4.4 Transformation of goals and allocation of resources	120
4.5 Managing the process of implementing sustainable energy management	123
4.6 Control and audit of the strategy	128
4.7 Case study – Canada	136
5. Methods and Techniques for Implementation of Sustainable Energy Management	
5.1 Basic approaches to implementing strategy of sustainable energy management	141
5.2 Traditional approach	142

5.3	System approach	145
5.4	Eco-management approach	153
5.5	Total quality management approach	164
5.6	Life cycle analysis	176
5.7	Gap analysis	182
5.8	Case study – USA	190
6.	Energy Management – Control	
6.1	Elements of strategic control	211
6.2	Controlling financial effects of implementation	220
6.3	Controlling non-financial effects of implementation	222
6.4	Case study – Serbia	223
7.	Strategic Priorities of Sustainable Energy Development	
	First Strategic Objective – Exploitation of Renewable Energy Sources	
7.1	Solar energy	244
7.2	Biomass energy	251
7.3	Wind energy	277
7.4	Geothermal energy	288
7.5	Hydropower energy	293
7.6	Management of renewable energy sources	298
7.7	Economic effects of sustainable energy management	305
	Second Strategic Objective – Energy Efficiency	
7.8	Energy efficiency	307
7.9	Energy efficiency audits	310
7.10	Improvement of energy efficiency	314
	Third Strategic Objective – Risk Management in Energy Facilities	
7.11	Energy management risks	319
7.12	Basic steps of risk management	321
7.13	Risk assessment	323
7.14	Methods of environmental investments risk assessment	325
7.15	Case study – Sub-Saharan Africa	327
8.	Sustainable Energy Development Monitoring	
8.1	Indicators of sustainable development	336
8.2	Indicators of sustainable energy development	338
8.3	Determination of sustainable development level	341
8.4	Determination of sustainable development level by indicators of development	342

8.5	Determination of sustainable energy development level	345
8.6	Case study – Southeastern European Region	346
Conclusion		363
Glossary		367
Bibliography		369
Index		375

Introduction

Sustainable development is a comprehensive concept of development that was adopted in order to preserve the planet's resources to the extent that will satisfy the needs of present generations without compromising the ability of the next generation to meet the same needs. The concept is comprehensive, multidimensional, and multidisciplinary, and it can be applied widely.

The study of sustainable development involves considering the whole range of relevant issues, mechanisms, solutions, and critical attitudes. Currently there is no single concept of sustainable development that can be universally applied in all areas of human activity throughout the world, and it is necessary to examine it in some sectors that are of special interest for a certain range of issues.

Since the creation of contemporary mankind, especially with the progressive development of human activities, there has been a need for the provision and consumption of certain types and amounts of energy. Every activity is related to the pending charges of energy that are created, transferred, transformed and consumed.

Energy production and consumption is a special problem in the modern world and it needs to be understood on several grounds. First of all, with a proportional increase in population there is an increasing need for the provision of sufficient energy. Given the nature of population growth and inability to stop this growing trend, the problem of providing energy for all human needs becomes global and constant [63].

Energy needs are very different in different parts of the world. The highest energy consumption, since the beginning of the Industrial Revolution in the late eighteenth century, has been found in the most developed countries [65]. Consumption of large amounts of energy has brought these countries a significant economic advantage and created the need to face a constant requirement of providing sufficient energy for future economic and social development.

Energy consumption in the world can be defined and measured on several grounds, but the most suitable is the energy consumption in the total amount of time, in some regions, as well as energy consumption from particular sources.

The total energy consumption in the world undergoes complex monitoring and control, which has multiple objectives. First of all, monitoring of energy-related indicators in the world is necessary because it provides insight into the

general situation of the energy sector, helps identify the differences among particular regions, as well as understand the trends and predict future tendencies. Tracking energy-related indicators requires extremely complex measurements, so that accurate data can be obtained only after several years. The framework overview of energy consumption in the world until 2005 is shown in Figure 1.1.

Energy consumption has been measured in an organized and precise way since 1965. Power consumption in the world is characterized by three periods. In the base year 1965, energy consumption in the world was less than 5 Terawatts. Out of the 5 Terawatts, the largest portion was provided by exploitation of traditional sources (oil and coal), almost in equal ratios. Half that amount of energy was obtained from gas, and the least amount was obtained by exploitation of water energy. Even then, 1% of energy was obtained from nuclear power plants [64].

In the second period, which started in 1970, the energy consumption of petroleum was doubled and reached its maximum in 1980. Consumption of coal was also growing, but it was much slower and more balanced. Energy consumption increased steadily from gas, which can be partly explained by population growth and technology. The huge increase in consumption of petroleum can be understood only because of the increase in traffic. In this period (from 1980 to 1990), the consumption of water resources remained at the same levels, and the consumption of energy from nuclear sources grew slowly but not significantly.

The third period began in 1990 and is characterized by the beginning of a stable and balanced growth in energy consumption from traditional sources. Consumption of oil and gas continued to grow almost evenly, while the consumption of coal was stabilized and even slightly reduced by the end of the period. Production of energy from water and nuclear sources reached its peak in 1990 and there were no significant changes until 2000.

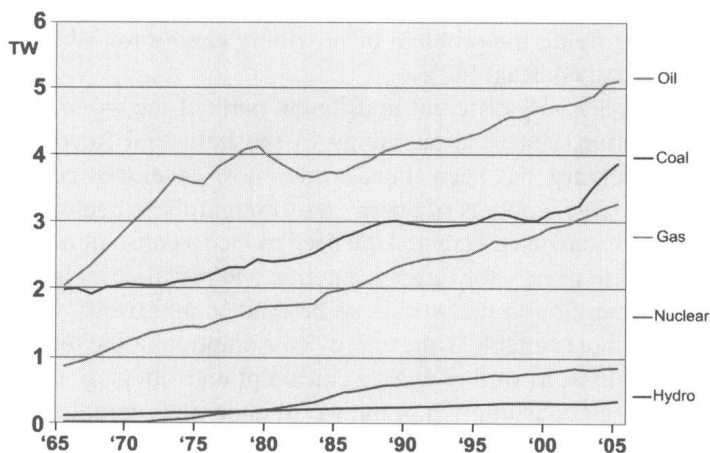


FIGURE 1.1 Energy consumption in the world until the year 2005

In the beginning of the new millennium, by a shift in the third distinct period, energy consumption from oil and gas continued to grow at the same pace, while the consumption of energy obtained from coal, after a decade of stabilization, began to grow again. At the end of the third period, in 2005, for which the precise data is available, the total world energy consumption was less than 15 TW, three times more than what was recorded 40 years earlier [75].

The reasons for increased consumption are numerous and complex and include the increase in the number of people in the world, improvement of the needs of industry and transport, inefficient consumption, and poor energy efficiency indicators. Whatever the reasons, this large consumption of energy, apart from the exhaustion of the world energy resources, has led to significant environmental consequences. All of which raises the need for a strategic redirecting in the field of energy management at all levels, with the knowledge that energy consumption is uneven in some parts of the world, as shown in Figure 1.2.

Along with the monitoring of the total consumption of energy in the world, the monitoring of energy consumption in some regions of the world is connected with a number of problems, so final estimates cannot be considered absolutely accurate, although they provide valuable information about the approximate values of energy consumption.

The highest energy consumption can be seen in the United States, Canada, Norway, and Saudi Arabia, which can be largely explained by the high level of technological development and living standards, as well as the intensity of traffic. Somewhat weaker consumption has been recorded in Russia, Scandinavia, and Australia. Compared to the first group of countries, with the highest energy consumption (indicated above), the European countries, Japan, South Africa, and Argentina, spend half that energy, followed by the Eastern European countries.

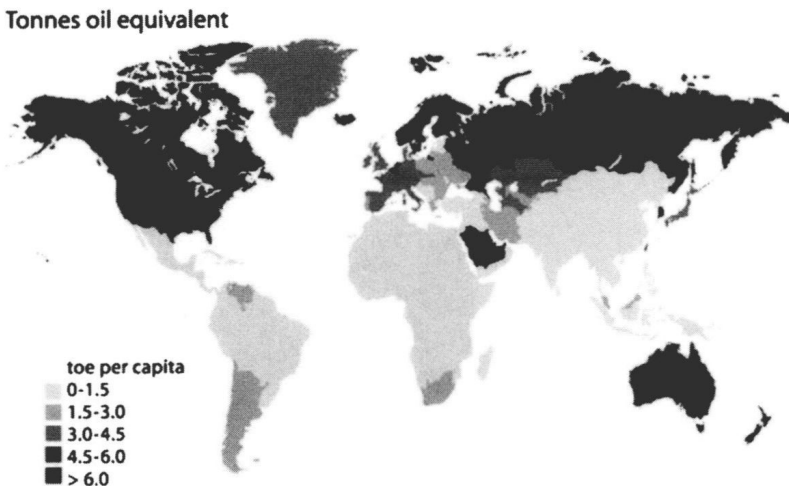


FIGURE 1.2 Regional distribution of energy consumption in the world

Even lower power consumption has been recorded in Brazil, and the lowest in Africa and the Far East.

Energy consumption in some regions depends on many factors, but it is evident that it is related to the question of whether the region also produces the energy. Countries with the largest energy reserves are also the biggest consumers of energy, which can not necessarily be considered justified. The European countries are mainly well-developed countries, but they do not use too much energy, which is mainly due to the great efforts for rational management of energy [7].

Consumption of different types of energy also has its particularities, which are shown in Figure 1.3 [77].

From the beginning of the industrial revolution (technical and technological improvements and expansion of transport) energy from oil is mostly used, and one-third of the world's energy needs is provided in that way. Apart from this, the trend of oil consumption is obvious. Over the years, oil consumption has continued to grow and that trend is expected to continue. Somewhat less energy is obtained by exploitation of coal (25%), but that trend has decreased, which can be explained by specific technological processes and the use of automobiles that cannot use coal as fuel. About one-fifth of world energy demand is obtained by the exploitation of gas [12].

The remaining quantities of energy are provided in the same proportion of energy from the biomass (11%), nuclear (6.4%) energy, and water courses (21%). Exploitation of nuclear energy is limited to countries where such production is allowed. The least quantities of energy are obtained from alternative sources (2.2%). The average general values have been presented, but it should be emphasized that there are significant differences in certain countries and regions [6].

Taking into account the energy dependence of developed countries and the uneven distribution of energy resources, production and distribution of energy

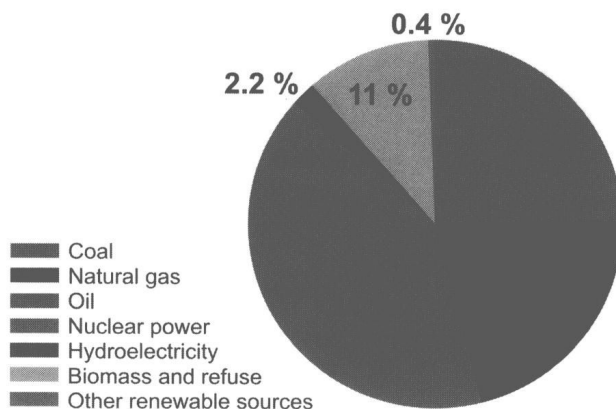


FIGURE 1.3 Energy consumption in the world by the type of energy

has become a problem of particular international political and economic importance. Energy in all its forms has become a subject of international trade, numerous disputes, negotiations, and military conflicts. Since the demand for energy on the planet is constantly growing, it will occupy a more important place in global economic and political changes in the future.

With the development of awareness and responsibility of individuals and businesses and countries with the objective to respond to the growing number of environmental problems, the concept of sustainable development has been defined to seek options for successful solutions to the environmental problems, including energy exploitation and consumption, which are connected with substantial negative environmental impact. The problem of providing sufficient energy is one of the main challenges of sustainable development and clearly breaks the trend of uncontrolled energy consumption and implicitly imposes the need for changes in this field.

Sustainable development involves, among other things, the gradual implementation of specific measures to drastically change the current approach to energy production and consumption, because it implies developing new technologies, utilization of new energy sources, development and implementation of comprehensive measures of saving, and the development and implementation of numerous legal regulations, all with the aim of raising levels of energy efficiency, i.e., to stop the trend of uncontrolled consumption of energy that inevitably leads to the rapid and total depletion of existing energy resources [78]. These measures are binding for all countries that accept the concept of sustainable development and are a part of many international agreements and protocols that govern this area.

The energy problem, with the need for economic development on the one hand and the need to keep energy resources and reduce pollution on the other, requires definition of a special mechanism to manage this area, which is essential to the process of planning at all levels, in companies, across regions and countries, and in the international community as a whole [79]. Sustainable energy management, with all the elements of modern management science, along with the integration of requirements that are set by implementing the concept of sustainable development, is an effective mechanism that allows long-term planning of sustainable development. Sustainable energy management is designed so that its steps are clearly defined and measurable and its goals are specified and measurable. Only this model of management, which is based on the impact of the factors of sustainability, with clearly defined goals, provides quality monitoring of the progress of the whole process of sustainable development. However, in sustainable energy management the impact that energy exploitation and utilization of energy resources may have on other indicators of development can be monitored, measured, and kept under control.

Sustainable development consists of four subsystems that are interconnected although different in nature and intensity. The economic, environmental, social, and institutional subsystems are a kind of sustainable development unit, whose

harmonious development represents the best possible option for long-term, stable development and survival of mankind. Energy management is a key problem of sustainable development because energy consumption reduces the values of the environmental subsystem but has positive effects on the values of the economic subsystem.

Sustainable energy management enables the monitoring of economic and ecological parameters of development because it includes the exact methods for assessing the effectiveness of implementation, and the control is based on a method for determining the degree of sustainable development through measuring its indicators. Defined in this way, the sustainable energy management model can provide real insight into the level of achieved sustainable development as a whole, taking into account that determining the balance between the economic and ecological development is particularly important [38].

Sustainable energy management is designed to provide a management model that can be accepted not only by individual companies but by countries or regions that create a geographical, natural, and economic unit. The sustainable energy management model is based solely on determining the most appropriate form of management of the system of future energy production and consumption, indicating the most important objectives in the field of sustainable energy development, pointing out how these goals can be achieved, and controlling the complex process by applying the methodology of assessment of the achieved degree of sustainable development. Only in this way is it possible to plan, organize, monitor, and control the complex and complicated process of energy management in the modern world.