Today, basic energy sources are fossil fuels – coal, oil, and natural gas. Coal was the most important energy source in 18th century, while coal and natural gas emerged at the end of 19th century. These energy sources provide 90% of energy in the world. They are formed as a result of plants and animals rotting for thousands of years. Their basic feature is their quicker depletion compared to their production. According to different studies, supplies of oil and natural gas will be enough for the following 40-60 years, while the supplies of coal for the next 200 years. Burning these solid and liquid fuels causes pollution and other harmful effects on ambient air. A continuous increase of average temperatures in the world is a statistical fact and it is called global warming. A main agent for global warming is enhanced concentration of carbon dioxide in the air. This concentration causes an effect of slimming particular parts of the Earth’s ozone layer. Results of this slimming are a rise in sea level, people suffering from temperature stress, gradual extinction of different kinds of animals, crop destruction, spread of tropical diseases, etc. Another harmful effect of the usage of the abovementioned fuels is acid rains. They cause fatal destruction of woods, flora and fauna in water pools, as well as gradual destruction of buildings and century-old cultural monuments. As a result of burning the before-mentioned energy sources, air quality in big cities all around the Earth has worsened. After the mid-20th century, nuclear fuel was considered a potential energy source. At the beginning, it was thought that it would entirely replace all other fuels. Gradually, these forecasts have become less optimistic because the supply of uranium is limited and there have also been accidents at nuclear plants worldwide. One of the main problems in using nuclear energy is the problem with a deposit of nuclear scraps.

Since the population of the Earth increases, there are more people who need energy. Also, of course, the demand of energy continues to increase (IEA, 2006). Recently, special attention has been paid to the use of renewable energy sources – sun, air, water, geothermic energy, bio mass. The increase in using renewable source energy is expected to decrease the hothouse gases and cause an improvement in air quality. For the time being, the main emphasis has been placed upon the positive effects of renewable sources. There is a possibility that they can also have negative effects but until this stage of usage, it is impossible to assess them.

The development of science and technology is not only an integral part of advancing human civilization but is also, in a great degree, a formative part of its progress. The discovery of electrical energy started a new era of the human progress. A need to convert energy of different sources into electrical energy has arisen. Every day we witness more and more significant achievements where natural resources are used, for example in spacecraft. Recently, there has been rapid development of information and communication technologies connected to the possibility of processing a large quantity of data with high speed, and of data transfer around the Earth and into space. Furthermore, we observe development in the field of material science a result of new treatment technologies. Moreover, achievements in using the contemporary computer, as well as communication and electronic technologies in medicine are extremely significant. Operation of the technical means and equipment applied in the above mentioned
fields is impossible without using electrical energy at current stage of human development. Electrical energy usage for different needs increases and, at the same time, traditional energy carriers are replaced (Bertoldi, 2007). An example is a car with hybrid motion.

Individuals are accustomed to methods and processes and even to the most ordinary aspects of electrical energy that they consider them to be something that has always existed. Sometimes, in those moments when a common way of their lives changes as a result of absence of electrical energy, they have to question this assumption. Fortunately, these moments are, for the greater portion of the Earth’s population, very rare and they are quickly forgotten. Individuals in different countries have connected their professional lives with the processes of generation, distribution, conversion and consumption of electrical energy for variety of needs. Knowledge in the field of electrical energy has been passed from generation to generation of specialists. This handing over process will also continue in the future. Recently, there has been increased activity in scientific research connected to new energy sources and to the increase of power efficiency. Different research programs concerning new energy sources are financed at international and national levels. The importance of solving tasks is proved by the fact that funds come not only from medium and large enterprises but also from different governments. In many countries, special groups, such as committees, agencies, etc, are founded to operate in the field of power efficiency.

The primary equipment connected to human activity in industry and everyday life operates using electrical energy from the electrical supply network. Most consumers are sensitive to changes of power quality. Its deviations cause undesired results such as fault operation. The consequences are unpredictable and relevant not only to economic resources and time but sometimes also to humans. Such critical consumers are everywhere around us – at technological process control, banks, hospitals, airports, telecommunication apparatus, in warcraft, during obtaining oil or using atom energy, in space, etc. To secure equipment’s flawless operation, different solutions have been applied and are applied. One of the most popular solutions is the use of uninterruptible power systems.

The processes of generation of electrical energy, its conversion and distribution, and its storage and rational use again as electrical or other types of energy of a certain quality and sometimes as an uninterrupted source, are a question of continuous study and improvement. A major share in these processes is taken by Power Electronics, whose objects are power electronic converters. The converters are complicated technical products and they are basically a combination of power schema, based on power semiconductor switches, and a control system. Generally, at the input of the power electronic converters AC or DC power, generated in different ways, is applied. Moreover, the power electronic converters have to give at their outputs AC or DC power in accordance with a load type. Proceedings with different orientations in the field of electrical energy conversion are available at the market. Most of them are strictly specialized and they scrutinize topics connected with the converters’ operation.

Under the formed trends of enlarging the usage of energy as electrical energy, the problems to increase power efficiency have appeared to be of great importance. Usually, these problems are topics of articles published at specialized proceedings and conference papers. They present a particular solution of a problem.

The purpose of this book is to present to readers an overall description of electrical energy conversion technologies and required power electronic converters. During the description, special terms and specific methods, which require a preliminary background, are used. But the main attention is paid to indicators of these converters that determine power efficiency. From this point of view during every discussion, contemporary achievements and emerging trends to increase power efficiency of the power electronic converters are presented. The operation of their control systems is of great importance to proper operations of converters. Chosen control algorithm and used element base for converter implementation mainly determine its whole operational reliability. The control systems have different special features depending on the electrical energy converter type, source and load. Thus, it is necessary to allocate space
to discuss them during illustration of the particular converters. After the reader has become acquainted with technologies for electrical energy conversion and equipment needed, it could be interesting for him or her to discover where and how they are implemented in different fields, for example in industry, transportation, home appliances, etc., also, to find out the possibilities of these converters to convert energy of the renewable energy sources and what are the trends for the conversion.

Developing processes of globalization and free exchange of information could be considered not only as processes between scientists and specialists in separated fields, working in different parts of the World, but also as processes requiring the information of strictly specific fields to be made accessible to people working in other fields without material similarity among them. Usually, the deep knowledge in the field of energy conversion requires specific preparation which can be obtained at the existing specialized technical universities. Very often, graduates from different levels of engineering study successfully communicate among themselves, but it appears as if they are isolated from people working at humanitarian or economic fields. Therefore, this book is written in a simple and easy way that will make it understandable for specialists in fields other than engineering. This book will contribute to enhancing the possibilities of communication about the problems of power efficiency at energy conversion among a variety of specialists. Perhaps new ideas, whose solutions may be found in the future, can arise. I have reached these conclusions as a result of service for many years as a lecturer and researcher in an extremely interesting field – Power Electronics. To be able to make essential achievements in this field, mankind should incorporate the efforts of a variety of specialists because of Power Electronics’ interdisciplinary character. Guided by these thoughts and ideas, I decided to present the information in the book in the following basic sections:

**Chapter 1 “Energy and Energy Efficiency”** identifies the present state and trends of the use of electrical energy in emerging and developing and advanced countries. The trends are determined by the economic activity of the emerging and developing countries and by geopolitical plans of the advanced countries and also by those countries which have basic energy resources. History of the recent past is presented. The forecast for development of the World Energy Market divided by different energy source is included. There is a discussion on the use of these sources per basic sectors - transportation, industry, commercial and residential sectors. Possible ways to increase energy efficiency during the processes of producing, transportation and using energy are described.

**Chapter 2 “Storage and Usage of Energy”** reviews ways and technical means to store energy as electrochemical, electromagnetic, electrostatic and mechanical energy. Storage of energy as different kinds is enforced because it is impossible to always consume energy at the moment of its generation. Also, in different occasions, the produced energy should be stored as a reserve one. The trends and forecasts show an increase of energy used as electrical energy. Therefore, energy conversion is required in accordance with a source – AC or DC electrical power, and with a consumer’s type – AC or DC load.

**Chapter 3 “Power Electronics and Its Role in Effective Conversion of Electrical Energy”** treats the large share of Power Electronics into the energy conversion. Power Electronics’ ability to increase power efficiency during the stage of transmission and use of electrical energy is discussed. Power electronic converters are basically a combination of power schema, based on power semiconductor switches, and a control system. The power electronic converters are complicated devices with a complex character; thus, when designing and implementing them, the knowledge and experience of experts in different fields of science and technique are required. Emphasis is placed upon interdisciplinary nature of Power Electronics. The reader can find a description of a long process of implementation of a power electronic converter from a scientific idea to its batch production. Finally, I pay attention to the use of computers in simulating the operation of power electronic converters and the study of different physics processes. A review of available software for simulation and study is made.
Chapter 4 “AC/DC Conversion” scrutinizes schemas and operational principles of single-phase and three-phase uncontrolled rectifiers, single-phase and three-phase controlled rectifiers, as well as bidirectional converters when an AC source is available. Emphasis is placed upon the indicators of the converters in respect to the source – power factor and harmonic spectra of source current, also, upon different methods to increase the power efficiency in AC/DC conversion. Requirements and structural schemas to implement control systems of AC/DC converters are presented.

Chapter 5 “AC/AC Conversion” presents schemas and operational principles of single-phase and three-phase AC regulators. There is also a review of the indicators of the regulators that determine the electromagnetic compatibility to the source network – power factor and harmonic spectra of the consumed current. As this chapter concludes, methods and schemas to increase power efficiency in AC/AC conversion are presented. Requirements and structural schemas to implement control systems of AC/AC converters are also presented.

Chapter 6 “DC/DC Conversion” analyses schemas and specific operational characters of converters without galvanic isolation - buck, boost, buck-boost inverting, Cuck-converter, SEPIC-converter, followed by the analysis of galvanic isolated converters - forward, flyback, push-pull, half bridge and full bridge converters. Then, a review of schemas and operational principle of bidirectional DC/DC converter is made. Basic special characteristics, which determine converter efficiency coefficient, are defined. Methods to increase the efficiency coefficient and to improve electromagnetic compatibility in respect to the source and ambient area are shown. Moreover, Chapter 6 reviews schemas of DC/DC converters with a soft commutation, which uses a resonance operational principle. Requirements and structural schemas to implement control systems of DC/DC converters are presented.

Chapter 7 “DC/AC Conversion” is a description of schemas and operational principles of single-phase and three-phase converters, which have AC output when a DC input voltage is applied. These converters are known as inverters. Different control methods used to improve harmonic spectra of the output voltage are studied. A relationship among the basic indicators of the inverters and the chosen control method, as well as the methods to improve these indicators, is described. Requirements and structural schemas to implement control systems of DC/AC converters are presented.

Chapter 8 “Conversion of Electrical Energy in the Processes of Its Generation and Transmission” describes power electronic converters used in the processes of generating and transmitting electrical energy at a distance. Methods and schemas used in HVDC transmission, as well as methods to increase the power efficiency under this transmission, are presented. Furthermore, I describe the possible decisions for compensating the reactive power and improving current harmonic spectra in already implied equipment – static compensator of reactive power, active power filters and unified power quality conditioner.

Chapter 9 “Conversion of Electrical Power from Renewable Energy Sources” discusses the use of energy of renewable sources – sun and wind. Energy conversion requires different types of converters to be combined. The choice of the converters and their compatibility defines the power efficiency. Here, I show the special characteristics of the converters for renewable energy sources – photovoltaics, windgenerators, and also I show their basic characteristics. In addition, I also describe the principle of distributed generation of electrical energy and special operation characteristics of final output inverters connected to the source distribution network. Recently, together with these alternative sources for generation of electrical energy, generation of energy using fuel cells has become a question of a great interest. The final fact is valid not only for the automobile industry but also for other needs. This is the reason why the special features of the converters, which can be used with fuel cells, are listed. The probabilities to increase converter power efficiency are also listed. In the last section of this chapter, different structural schematics of converters of water energy applicable in small Hydro Power Plants are included.

Chapter 10 “Uninterruptible Power Supply Systems” analyses methods and schemas to insure uninterruptible supply for so-called critical consumers, which are crucial to the quality of AC source
voltage. Possible disturbances of the quality are examined. Uninterruptible power supply systems (UPS) are a combination of an energy storage element and different converters for this energy. The converters convert the energy producing AC output voltage. Principles to implement dynamic and static UPS are included. I describe principles to implement passive standby, line interactive and double conversion UPS. Also, I analyze methods to implement supply systems with enhanced reliability using several AC voltage sources and UPS. The communication between UPS and other systems is also represented.

Chapter 11 “Other Applications of Converters and Systems of Converters” presents applications of converters and systems of converters in the following fields: industry, transportation, home appliances and communication technologies. Induction heating, welding, electrolysis, and air purifying are discussed from the industrial applications. Chapter 11 describes the converters applied for the needs of different vehicles. Contemporary energy efficient lighting also requires energy converters. Methods and schemas for lightning implementation are included in Chapter 11. Electrical energy converters applied in different home appliances are shown. Furthermore, electrical energy converters ensuring the operating reliability of different applications in communication technologies are discussed. Finally, special attention is paid to the requirements for electrical energy converters in medicine.

Chapter 12 “State-of-the-Art Review on Power Electronics” aims at introducing several of the most recent achievements and research directions in power electronics field to the reader. Thus, readers who are already acquainted with the content of the book up to this chapter have an additional opportunity to see the basic trends in development in this interesting field. Information from scientific publications as well as from different materials published by companies known for their practical expansions are used for the conclusions made.

The Appendix includes harmonic analysis of some periodical functions applicable in power electronics. The analysis is made to facilitate the reader studying the different parts of the book. Also, probabilities of using several software programs to make analyses in power electronics are shown.

It is obvious from the contents of the chapters that the reader can get acquainted with many different features of electrical energy conversion after thoroughly reading the presented book. It is recommended to read this book according to the order of the presentation, chapter after chapter. Readers who have theoretical and practical backgrounds can find individual topics for them in the book by reading only selected parts of it. Readers who do not have engineering education should read Chapters 1, 2, 3, 8, 9, 10, 11 and 12. This book gives basic knowledge of electrical energy conversion and also emphasizes methods and means to increase power efficiency at that conversion. In this way, this book succeeds in its general aim – to be useful for a wide circle of readers working in different fields. I am pleased to bring it to the readers’ attention and hope that its reading will content them.

Mihail Antchev

REFERENCES
