

## Preface

This book covers a very important topic in the field of power system engineering science and best practices. It aims at providing the reader with a deep insight of the fields involved in the power system planning process comprehensively. Moreover, this book blends the theoretical and practical aspects of power system planning.

Energy is considered one of the most important inputs for the social and economic development of nations. It is indeed vital for better life and higher levels of comfort and welfare. Energy provides fuel for life and for prosperity of nations. Therefore, it is sometimes used as a basis to differentiate between countries that “do” and countries that “don’t” have it as a proxy for strength of economy or political influence. Energy sources comprise conventional and renewable. The conventional resources are not only limited in quantities, but they are responsible for environmental pollution. On the other hand, renewable energy resources are environmentally benign, but unfortunately still not cost-effective as much as the conventional ones.

The total world primary energy supply for 2010, as per the IEA and OECD sources, was over 12,000 mtoe (million tons oil equivalent). This is expected to increase to 14,500 mtoe by year 2020. If the value of one ton of oil (at current prices of US\$ 100 per barrel) is equivalent to US\$ 750 then the value of the amount of oil equivalent in 2010 was almost US\$ 9 trillion. This figure indicates the importance of energy in the overall world economy as its value equals about 12% of world Gross Domestic Product (GDP). On the other hand, electricity production worldwide reached about 18,700 TWh (terra watt-hours) in 2010 according to IEA sources. If this is considered being worth 4-5 US cents per kWh, then the total value would be almost one trillion dollars. This again is a very large figure indicating the importance of the electricity sector to world economy. Therefore, any increase in efficiency of use or exploitation of more efficient technologies would mean large savings. On the other hand, the future does not seem to have good news as prices keep increasing and other problems related to energy and power get complicated. This would be reflected negatively on all economic sectors as well as on the level of comfort and entertainment of people.

The power sub-sector represents an essential part of the energy sector in any economy. It is unique in the sense that it is a commodity and a service at the same time. Electricity operates all sorts of machines and appliances that fill our homes, schools, stores, offices, and even streets. It has strongly penetrated all markets and applications. It strongly competes with all other forms of energy and surpasses them in being a clean source. Furthermore, electricity does not need any storage or waiting time to be served as it is an “instantaneous” service. The precise knowledge of future evolution of power systems will help greatly in planning the development activities correctly and exactly; thus avoiding under-or over-planning of future supply. The planning process is a combination of science and foresight. It needs special skills and demands knowledge of other disciplines.

The need to compile and organize power system planning methodologies that are based on both theoretical and practical knowledge is very much in place. Every power company has its own methodologies and planning practices. However, they might not be presented and elaborated in one document. Moreover, since these methodologies vary in extent, level of sophistication, accuracy, need for data, it is very prudent to attempt to come up with a book that covers all aspects of power system planning.

This book was conceived and written over the past two years, and it represents the output of several years of experience in power system planning followed by several years of teaching university students power system operation, control and planning. The two sides; theoretical and practical, hopefully combine to yield the best combination with the most benefit to readers and scholars. The authors have a combined work experience of over 50 years; half of which in the planning process of the power industry. The authors also depended heavily on research work conducted at the university with the cooperation or assistance from ex-colleagues at the electricity companies. The combination of this body of knowledge is an important element in enhancing the value of the book.

The book is self-contained and thorough and suits the needs and is of great benefit to different categories including: a) academia where it is proposed to be taught over two semesters for undergraduates, or in one semester postgraduate course, b) professional engineers in the area of electricity planning, c) practical trainees attending training programs or specialized workshops, and d) regulators, policy and decision makers in the power industry.

Very few existing books, not more than the number of the fingers of one hand, deal specifically with power system planning. Few other books cover topics related to power system planning. Investigating the contents and coverage of the books that deal directly and specifically with power system planning reveals that they deal only with the process of expansion of the system and the related mathematical and analytic tools related to this core function. In other words, they concentrate on the science of power system planning. They do not cover as much the art and the good practices that have evolved within the power industry. Moreover, the relationships and interactions between the planning and other business functions within the power industry or energy sector at large are not covered in the existing books.

The contents of the book are diverse and cover topics that tackle various practices and functions needed for proper planning of the power system. Each chapter could stand on its own as a subject for training course or as a special topic. Moreover, the sequence and order of chapters is well suited within the actual functions of power system planning.

This book is organized into 14 chapters. Each chapter is independent with a standard structure starting with chapter objectives, an introduction, case study, summary, and references, in addition to other specific sections.

The book starts, in Chapter 1, with the definition of the power system and its components. Then it discusses the planning process in general and planning of power systems in particular, and tackles different aspects related to this process. This introductory chapter provides the reader with a background about the components and various functions of the power system. It also discusses the tasks and activities included in the planning process. The chapter provides a clear layout of the interrelationships among the various functions of the planning process representing the various chapters of the book. Current issues related to power system planning are also investigated. These issues give the reader clear ideas of the scope of their application and effects on modern power system planning.

Chapter 2 is dedicated to regulatory and market constraints. This is an essential chapter in power system planning especially in light of the new trends of privatization and market deregulation. It also covers the environmental considerations, which occupy an important part in the shaping of future alternatives and related decisions. These topics discussed chapter 2 form essential issues and constraints affecting the future evolution of power systems directly and indirectly.

This is followed by Chapter 3, which is devoted to the planning criteria. It is the core of the planning effort as it forms the boundaries and refines the selection process. Planning criteria constitute the general framework and guidelines that govern the planning of power systems.

Load research is discussed in Chapter 4. This activity is responsible for data collection and compilation. Without such data no proper planning can be done. Load research is considered the heart of intelligence of the planning of power systems as it attempts to identify the characteristics and nature of consumption of the various consumers. The information generated by this activity is used as input for many other planning activities and functions.

Chapters 3, 4, and 14 comprise the preparation stage of the planning of power systems. In reality, Chapters 3 and 4 are the actual preparation steps needed for the planning, while chapter 14 is a general presentation of planning tools that might be needed in the process.

Chapter 5 deals with forecasting future energy and electrical loads. This activity attempts to foresee the future of system demand. Forecasting is considered by many as the core of the planning process. It is considered as the first step in the assessment and evaluation phase. It involves many tools and methodologies that need to be implemented. The outcome of the preparation stage is used as input for this essential activity.

Chapter 6 discusses energy efficiency methods and techniques. It is a very important activity for power companies as it decreases demand of consumers and, therefore, reduces future investments needed for new plants.

Similarly, demand side management is another activity that attempts to effect consumer behavior and habits in order to reduce future demand. This is dealt with in Chapter 7.

Renewable energy technologies are addressed in Chapter 8. All options to generate electricity from renewable energy sources are presented in this chapter with some special features of such alternatives.

Chapter 9 discusses the expansion planning studies. In this chapter the different concepts and methodologies are discussed. This analysis includes when to add a certain plant, in what site, size, technology used, and impact on system performance. Naturally, the plants here mean generation, transmission, and distribution.

All generation options including conventional, new, renewable, energy efficiency, and demand side management when taken together the planning is called Integrated Resource Planning (IRP). In other words, if supply and demand sides are considered in the future expansion of the power system it is then called integrated resource planning. This important topic is included in Chapter 10.

Chapter 11 presents the topic of system interconnections with other systems. Currently there is almost no power system that is not interconnected to other systems in the world. Therefore, interconnection has become a standard in today's power system planning, operation and control.

Investment will be needed to cater for system expansion and enhancing interconnection with other systems. Even performance improvement, update of outdated equipment, and improving customer satisfaction all need investments too. This is discussed in chapter 12, which is followed by tariff studies in chapter 13. Tariffs are designed to recover the costs of the electricity company plus some reasonable return on investment. On the other hand, electricity tariffs are very influential in all walks of life and business.

Finally, Chapter 14 presents a thorough discussion of all planning tools used in all phases and activities of the planning process. These include data collection, group thinking, decision support, and strategic planning tools.

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Finally, the authors have acted in good will in all aspects of the writing of this book to benefit the readers and intend no harm whatsoever. Positive and constructive comments and criticisms are also invited that will serve in enhancing the quality of this book.

*Fawwaz Elkarmi*  
*Amman University, Jordan*

*Nazih Abu-Shikhah*  
*Amman University, Jordan*

