

## Introduction

From the beginning of the 21<sup>st</sup> Century energy and environmental challenges have led to increasing electricity production from renewable energies. The concept of sustainable development and the concern for future generations challenge us daily, leading to the emergence of new energy production technologies and new behavior usage for these energies. The quick emergence of new technologies can make its understanding and perception difficult. The purpose of this book is to contribute to a better understanding of these new electricity production technologies by targeting a large audience. It presents the challenges, sources and their conversion process into electricity by following a general approach. It also develops basic scientific notions to comprehend their main technical characteristics with a global view.

The objectives of this book are:

- to present electricity production systems from renewable energy sources from small to mean powers (up to 100 to 200 MW);
- to introduce basic electrical notions that are necessary for the understanding of the operational characteristics of these energy converters;
- to discuss integration constraints and issues in the electrical networks of these production units;
- to set a few exercises for self-assessment.

Chapter 1 introduces the concept of decentralized electricity production from renewable energy resources. It presents the challenges that have led to the development of electricity production, not only just from the 20<sup>th</sup> Century centralized approach, but also dispersed throughout the territories. After all, the available resources that are managed by various actors in competition are also

dispersed. This chapter also presents the challenges that led to the development of electricity production from renewable resources. It introduces the various exploitable energies and describes the basic principles of their conversion into electrical energy.

Chapter 2 presents the direct production (photovoltaics) of electricity from solar energy. It describes the characteristics of photovoltaic cells and panels. It explains the operational principles of power electronic converters, which help to control the energy extracted from solar radiation and to transform it into the form required by consumers. The chapter ends with some exercises.

Chapter 3 develops the conversion principles of converting wind kinetic energy into electrical energy. It describes the main wind turbine technologies. It also explains electro-mechanical conversion from synchronous and induction generators, at fixed and variable speed. Examples of the characteristics of effective high and low power wind turbines are also provided. Exercises concerning various types of wind turbines at fixed and variable speed, the characterization of a wind turbine and the estimate of the generated power are also proposed.

Chapter 4 introduces electrical energy production from the potential or kinetic energy of water, whether in a terrestrial or marine environment. At first, the principles of hydroelectricity (the first renewable source producing electricity, which has been implemented for more than a century) are developed, by focusing more specifically on the running of river hydraulics. Secondly, water power coming from marine sources are presented: wave, marine current and tidal power. The exploitation of these energies is still not very developed and most of the associated technologies are just emerging, except for tidal power production, which is quite mature but still marginal. A few examples of these technologies will be described in this chapter. Some exercises in the context of a small river hydroelectric power plant and a tidal power plant are also proposed.

Chapter 5 introduces the concept of thermal electricity production, in which heat is produced from renewable resources. This is the case for geothermal power, for concentrated thermodynamic solar power and for cogeneration, whose principles are described. The operational principles and characteristics of the synchronous alternators directly coupled to the electrical network are also presented.

Chapter 6 raises the question of the integration of renewable energy sources and more, generally, of the decentralized production into electrical network. The latter are indeed confronted with a new paradigm, because of the random and unpredictable nature of some of these sources, due to their scattering on the territory, and because of the rules of a liberalized electricity market. The main connection

constraints of these sources are also briefly described. Perspectives for a better integration into the networks of these sources are identified by considering actions on the levels of the sources, networks and consumers. Developments and incentives are initiated, so that the future electrical networks become smarter.