

Preface

In the last years, the weight of solar electricity in the energy mix experienced an impressive augment and this trend is expected to continue. It means that a higher number of solar power systems, photovoltaic or solar-thermal, with inherent variable weather dependent energy production, are fed into the grid. As a result, forecasting the output power of solar systems, for the next minutes up to several days ahead, are of high importance for proper operation the grid. Accurate prediction of solar irradiance is of utmost importance, as this is a measure of available *fuel* of the solar power generator at a given future moment of time.

Apart from wind resources where the forecasting of wind speed is in a rather mature stage, forecasting of solar energy is just in an early stage. In the last years, a few projects dedicated to this matter, like European COST Action ES 1002—Weather Intelligence for Renewable Energies,³ were deployed around the world. Many research groups started to put great efforts into enhancing the performance of the actual models or to devise more performing better.

The forecasting of the output power of a solar system involves modeling tools which generically should exhibit two functions: first, to predict the solar resource and second, to model its conversion into electricity. A large variety of models and approaches can be considered for implementing the first function. For nowcasting solar irradiance, statistical extrapolation of measurements seems to be an adequate approach, while for tens of hours ahead numerical weather prediction models represent the best solution. For fulfilling the second purpose, the model is chosen in respect to the application: solar-thermal or photovoltaics. All these demonstrate that the syntagma *forecasting the output power of solar systems* covers a very large area of research from atmospheric physics and meteorology to physics of solar cell and advanced electronics.

This book is focused on two subjects: (i) modeling and nowcasting of solar irradiance at the ground and (ii) modeling the output power of PV converters in specific operation conditions. Models developed by the authors along with other

³ COST Action ES1002 Weather Intelligence for Renewable Energies, <http://www.wire1002.ch>.

models reported in the literature, accompanied with computational and handwork illustrations, are discussed in the book.

The eleven chapters are structured along logical lines of progressive thought. [Chapter 1](#) deals with the concept of energy mix, including a more detailed book outline in the last section. [Chapter 2](#) introduces terrestrial and satellite-based solar radiation measurements and surveys the largest solar radiation databases. [Chapters 3–8](#) relate solar regime with weather parameters, describing and assessing various approaches for nowcasting solar irradiance and forecasting solar irradiation. [Chapter 3](#) deals with the state of the sky assessment while [Chap. 4](#) is focused on different ways to characterize the solar radiative regime and its stability in a given period of time. [Chapter 5](#) surveys the algorithms for estimating solar radiation at the ground level, targeting the idea of their usage in nowcasting by inputting predicted values of weather parameters. [Chapters 6 and 7](#) are devoted to statistical extrapolation of measurements, being focused on ARIMA ([Chap. 6](#)) and fuzzy logic ([Chap. 7](#)) forecasting of clearness index on short-time horizon. [Chapter 8](#) proposes a simple way of predicting solar yield by using forecasted values of daily air temperature extremes in temperature-based models for solar irradiation. In the next two chapters, the issues of modeling the output of photovoltaic systems operating in specific weather conditions are addressed. Several models which translate the modules parameters from standard test conditions to real operating outdoor conditions are reviewed and illustrated in [Chap. 9](#). In [Chap. 10](#), a comparative assessment of the results reported in the literature regarding the forecasting of PV systems output are performed. Conclusions and perspectives are summarized in [Chap. 11](#).

The authors hope this book gathers information that may be useful to both researchers in the field of solar radiation forecasting and engineers engaged in power grid control. Also, parts of the book may be used for teaching undergraduate and postgraduate students in related courses.

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Operation

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