

WIND ENERGY SYSTEMS

Electronic Edition

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PREFACE TO FIRST EDITION

Wind energy systems draw on a wide range of disciplines. Any prospective user, regardless of his background, will feel large gaps in his knowledge, areas where he does not even know what the question is, let alone where to go look for the answer. This book is written to help people identify the proper question to ask.

There are several groups of potential users of a book on wind energy systems. There are those with non technical backgrounds who want a readable introduction. There are graduate engineers who need a detailed treatment of some aspect of wind power systems. And there are undergraduate engineering students who need a formal course in the subject. We have chosen the undergraduate engineering student as the primary audience, but have tried to consider the needs of other users. Many of the key concepts should be readily understood by those with a good high school education. Those sections which demand a more technical treatment, however, assume a background in chemistry, physics, calculus, circuit theory, and dynamics. Rather detailed treatments of meteorology, statistics, electrical machines, and engineering economics are given, but since these subjects are not studied by all engineers, no background is assumed for these areas. Enough detail is included so that a technically trained person can evaluate a given system for a proposed application and also learn enough of the specific language that he can look elsewhere for more information in an efficient manner.

This book will be of interest to those students who are interested in energy sources besides coal and nuclear. Oil and natural gas are obviously not suitable long term solutions to our energy requirements, and coal and nuclear energy face severe environmental obstacles. This means that the so-called alternative energy sources may well become primary sources over the next few decades. At the present time wind, solar photovoltaic, and solar thermal systems appear to be the main contenders for supplying a substantial fraction of the energy requirements of the United States and much of the remainder of the world as well.

A number of books about wind power have been written in the last decade by those working in the field. These books generally have no problems at the end of the chapters, and hence are difficult to use in a formal course. The author believes that significant numbers of students in engineering or technology would be interested in a course on wind energy systems

if an appropriate textbook were available. It is hoped that this book will fill such a need.

An attempt has been made to pull together information from many sources and present it in a clear, consistent fashion in this text. Most of the material is available in the open literature, but some that has been developed from research at Kansas State University has not been published elsewhere. This includes some wind speed data and much of the material on induction generators.

Both large and small wind turbines are discussed. The person designing a wind farm of multi-megawatt machines connected to the utility grid should find the necessary background material here, as well as the person desiring to install a small battery charging system in a remote location. Information is included on piston pumps, centrifugal pumps, batteries, electrolysis cells, and other topics that may be important in certain wind power applications. Much of this information is difficult to find in a concise form elsewhere, so this should increase the usefulness of the book.

The field is evolving rapidly, so some specific examples will become obsolete quickly. An effort has been made, however, to present the basic information that is not likely to change, so the book will be useful for a number of years.

It has been the author's experience that the quantity of material is ample for a three hour course. The instructor may need to be selective about sections to be covered. Chapters 2,4,5, and 8 are viewed as the heart of the course, and the other chapters can be omitted, if necessary, with little loss of continuity. The book has been classroom tested over a five year period and much of it has been rewritten to include improvements suggested by the students.

SI units have been used extensively throughout the book, with English units used as necessary to bridge the gap between present practice and the anticipated total conversion to SI units. A list of conversion factors is given at the end of the book.

A good selection of problems is given at the end of each chapter. Some problems require the use of a programmable hand calculator or a digital computer. These can be used where all the students have access to such equipment to give additional practice in computational techniques.

The author wishes to express appreciation to Theresa Shipley and Teresa Gallup for typing various versions of the manuscript. He also wishes to thank the many students who offered suggestions and criticisms. Finally, he wishes to thank his wife Jolene, and his children, Kirk and Janel, for their patience during the writing of the book.

PREFACE TO SECOND EDITION

A ninth chapter, on wind farm layout, has been added to the second edition. This discusses topics like wire and transformer selection. We actually start the semester with this chapter

and Chapter 8, so we can give a wind farm design project early in the semester. Each student is asked to do a paper design of a wind farm, including layout, sizing of components, and economic analysis. This design has worked very well, helping to make the course one of the most popular elective courses in the department. There were 46 in the course Fall 1993, which was the largest enrollment of any elective course in the department. The chapter has enough tables on wire sizes, wire costs, transformer sizes and costs, and other costs that the student can feel confident of doing a respectable design without seeking other sources of information. Each student is given a topographical map and an aerial photo of a particular square mile at one of five sites, and performance data for a particular turbine or two at that site. One student may have a flat site while another may have one with hills and sharp ravines. Some sites have railroads or pipelines. Each student has a different design to do, which greatly reduces concern about copying, but still the difficulty of each design is approximately the same. The deadline for designs is about two-thirds of the way through the semester, so there is ample time to grade them.

Once the designs are given, we go back to the start of the book and see how far we can get. We usually skip Chapter 3, and the portions of Chapter 5 that are covered in an earlier required course on Energy Conversion.

After Prentice-Hall let the First Edition go out of print, the copyright was returned to the author. This Second Edition is copyrighted, however, it is planned to grant a broad authorization to copy and/or edit any or all of this material to a school or other organization upon the payment of a one time fee. Any reader who is not already covered by an existing authorization should contact the author for details.

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PREFACE TO ELECTRONIC EDITION

The author took early retirement in May, 1994 and spent the next two years working as a consultant to a wind farm developer that was interested in establishing a wind farm in Kansas. A large ranch in southern Kansas was selected and three towers were instrumented, two at 40 m and one at 60 m. At the end of two years it was obvious that it would be several more years before wind farms were established in Kansas, so the developer walked away from the lease. The rancher and the author have continued to collect data since that time, confirming that the ranch is indeed a premium site. A number of developers and utilities have considered the possibilities, but as of this writing, the ranch is still available.

A number of copies of this book were photocopied and sold since 1994, and several organizations opted to buy the permission to edit and photocopy at will, as mentioned in the previous preface. But things have slowed down such that economically there is no point in continuing this process. While some of the prices are outdated, the author believes there is considerable basic information in this book that is still quite valid. Therefore the decision was made to scan in some of the figures and photographs and prepare these files in PDF format. The only change made was to put references at the end of each chapter rather than at the end of the book. Except for the photographs copyrighted by others, this material should be considered as in the public domain. May it yet serve a role in establishing wind power as a significant source of electrical energy throughout the world.

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