

PREFACE

Energy and Power Generation Handbook: Established and Emerging Technologies, edited by K.R. Rao, and published by ASME Press, is a comprehensive reference work of 32 chapters authored by 53 expert contributors from around the world. This "Handbook" has 705 pages and contains about 1251 references and over 771 figures, tables, and pictures to complement the professional discussions covered by the authors. The authors are drawn from different specialties, each an expert in the respective field, with several decades of professional expertise and scores of technical publications.

This book is meant to cover the conventional technical discussions relating to energy sources as well as why(s) and wherefore(s) of power generation. The critical element of this book will thus be balanced and objective discussions of one energy source vis-à-vis another source, without making any recommendations or judgments which energy source is better than another.

A primary benefit of these discussions is that readers will learn that neither this nor that source is better, but together they complete the energy supply for this planet. This perhaps could be obvious even without going through the compendium of energy sources covered comprehensively in a book. However, a unique aspect of this publication is its foundation in the scholarly discussions and expert opinions expressed in this book, enabling the reader to make "value judgments" regarding which energy source(s) may be used in a given situation.

This book has the end user in view from the very beginning to the end. The audience targeted by this publication not only includes libraries, universities for use in their curriculum, utilities, consultants, and regulators, but is also meant to include ASME's global community. ASME's strategic plan includes Energy Technology as a priority. Instead of merely discussing the pros and cons of "energy sources," this publication also includes the application of energy and power generation.

Thus, the book could be of immense use to those looking beyond the conventional discussions contained in similar books that provide the "cost-benefit" rationale. In addition to which energy source is better than the other and to which geographic location, the discussions on economics of energy and power generation will portray the potentials as well.

Instead of picturing a static view, the contributors portray a futuristic perspective in their depictions, even considering the realities beyond the realm of socio-economic parameters to ramifications of the political climate. These discussions will captivate advocacy planners of global warming and energy conservation. University libraries, the "public-at-large," economists looking for

technological answers, practicing engineers who are looking for greener pastures in pursuing their professions, young engineers who are scrutinizing job alternatives, and engineers caught in a limited vision of energy and power generation will find this publication informative.

Equally important is that all of the authors have cited from the public domain as well as textbook publications, handbooks, scholastic literature, and professional society publications, including ASME's Technical Publications, in addition to their own professional experience, items that deal with renewable energy and non-renewable energy sources. Thus, ASME members across most of the Technical Divisions will find this book worth having.

The discussions in this Handbook cover aspects of energy and power generation from all known sources of energy in use around the globe. This publication addresses energy sources such as solar, wind, hydro, tidal, and wave power, bio energy including biomass and bio-fuels, waste-material, geothermal, fossil, petroleum, gas, and nuclear. Experts were also invited to cover role of NASA in photovoltaic and wind energy in power generation, emerging technologies including efficiency in manufacturing and the role of NANO-technology.

The 32-chapter coverage in this Handbook is distributed into nine (IX) distinct sections with the majority addressing power and energy sources. Depending upon the usage, solar, wind, hydro, fossil, and nuclear are addressed in more than a single chapter. Renewable Energy Resources are covered in Sections I through IV, and Non-Renewable in Sections V and VI; Sections VII through IX cover energy generation-related topics.

Cost comparison with conventional energy sources such as fossil and fission has been made to ascertain the usage potential of renewable resources. This aspect has been dealt by authors while emphasizing the scope for increased usage of renewable energy. Authors therefore dwell on measures for promoting research and development to achieve the target of being cost-comparable.

Preceding all of Sections I through IX, biographical information pertaining to each of the authors is provided followed by Chapter Introductions. This information provides readers a fairly good idea of the credentials of the experts chosen to treat the chapter topic and a glimpse of the chapter coverage.

Section I, Chapters 1 through 6, deals with *Solar Energy* in 114 pages addressed by 10 experts from academia, NASA, and practicing professionals from the U.S., Europe, and India. Global interest in solar energy is apparent not only from the current usage but also from the untapped resources and its potential for greater usage.

The last chapter of Section I, Chapter 6, is authored by experts from NASA who elucidate NASA's efforts in both Solar and Wind energy sectors. This is appropriate since both of these energy sources constitute the most popular of the renewable energy resources.

In addition to the potential of *Wind Energy* already covered in Chapter 6, it is covered in detail in Chapters 7 through 10 of Section II. The increase in usage of wind energy in the past few years in the U.S. as well as in Asia and Europe surpasses any other energy resource. Thus, the potential, like solar energy, is enormous yet is vastly untapped. Global interest in wind as energy resource, although confined to countries uniquely located with wind potential, is limited by technological consequences. Authors from Sandia and Idaho National Laboratories, a research laboratory in the Netherlands, and a practicing professional from India discuss in 71 pages all of the ramifications of wind energy including the public perceptions and ways to technologically overcome environmental considerations including noise and visual aspects.

Section III deals with Hydro and Tidal Energy and has three chapters, Chapters 11, 12, and 13, devoted to *Hydro Power in the USA and Asia* in 40 pages. These three chapters are authored by three expert practicing professionals at the helm of their organizations and EPRI. Potential for this energy source is considerable in the U.S. and developing world, and lessons of experience with considerable "know-how" in hydro power are valuable for use in rest of the world. *Tidal and Wave Power* is unique and knowledge based, a privilege of the developed nations even though rest of the world have enormous potential for this energy source. This is addressed with abundant reference material by an expert from Electrical Power Research Institute (EPRI).

Section IV covers diverse modes of energy and power generation such as Bio Energy, Energy from Waste, and Geo Thermal Energy addressed in 56 pages in Chapters 14, 15, and 16 by practicing professionals and academia.

Bio Energy including Biomass and Biofuels is not exclusive to developed world. Even developing nations are aware of it although not dependent upon this source of energy. Bio-energy technology has been discussed by a practicing professional with expertise in this field in the U.S. and overseas. The author covers the potential of bio energy's future usage and developments, especially co-firing with coal.

Waste Energy has been addressed by a practicing professional with knowledge of municipal and industrial waste in both developed as well as underdeveloped or developing economies. Urbanization and concomitant suburban sprawl with demands for alternative sources of energy generation can release gasoline for automobiles. With the help of several schematics, the benefits and challenges of utilizing waste are covered including waste cycle, the regulatory perspective, business risks, and economic rationale.

This book that has as its target to investigate all "known" energy sources and *Geothermal Power* cannot be discounted now as well as in the immediate future. Even though confined in its application to a few isolated locations in the world such as Iceland, USA, Australia, Asia, and Europe, its contribution for solving global energy and power problems can be considerable, if this partially tapped resource of this planet can be harnessed to the fullest extent. Technological intricacies of this topic are addressed by two authors, an expert from the academia and in-charge of a professional organization in U.S.

In Section V, as part of *Non Renewable Fuels for Power Generation—Fossil Power Generation* comprising *Oil, Gas, and Coal Gasification* is addressed by U.S. experts in Chapters 17 through 20 in 86 pages. The cutting edge of technology concerning the impact of CO₂ emissions, climate change, and coal gasification is addressed by U.S. industry experts in this section. Both the U.S. and global economy are impacted by fossil fuel and power generation from petroleum and gas. This issue is addressed in this Section by two U.S. economists. Chapter 19 section will cover ongoing issues as well as the state-of-the-art technology.

While contributors cover the existing generation methods and technology, they also expound facets that deserve unique attention. For example, the fossil power generation industry, responsible for 40 percent of carbon emissions, can be addressed with a socio-economic impact largely by technological advances. As longer chimney heights and scrubbers were considered necessary for coal-fired units, technology has moved forward and there are items worth attention of the readers. 'The Details of these technological advances'!

A discussion about *Fossil Power Generation* is inescapable without an understanding of "global warming," "climate change," and the Kyoto Protocol for dealing with carbon emissions. The authors of Chapters 14 and 15 associated with a premier fossil fuel enterprise bring the wealth of their experience in covering the cutting edge of technology related to carbon emissions. If abundant coal in the U.S. has to continue for coal-fired power generation, a blessing instead of a bane, it has to transform the technology of the use of coal. Authors aware of the efficiency of coal-fired power generation, to meet the global competition, have, with impressive schematics and examples, implicitly demonstrated U.S. dominance in this field.

A unique aspect of this handbook is the inclusion of a section by two U.S. economists who provide economic rationale for petroleum and bio fuels. With the help of abundant schematics, the authors drive home the point that a value judgment has to be made beyond technical considerations economic parameters as well. The scope of coverage will include U.S. and developed economies of Australasia, Europe, and North America and developing countries including countries of Asia, South America, Africa, and the Middle East.

Previously, coal was converted to make gas that was used by customers. Recently, investigation has been progressing on "Coal Conversion." Technological advancement has prompted technologies such as gasification, methanation, and liquefaction. Author addresses state-of-the-art technologies in Chapter 20 including distribution and cost impacts.

The oil rig exploration on April 20, 2010 in the Deepwater Horizon 40 miles off the coast of Louisiana was the largest oil spill in the Gulf of Mexico, according to the U.S. Coast Guard. This issue has not been addressed in the discussions of Section V, since it would distract from the main theme of the subject matter.

In Section VI titled *Nuclear Energy*, seven U.S. authors from each from Japan and Switzerland cover Chapters 21 through 27 in 67 pages. Throughout the world, the nuclear industry is experiencing a renaissance. The aspects addressed in this Section include a self-assessment of the current generation of Nuclear Power Plants, much as covering salient points of the next generation of Nuclear Power Reactors. These and other issues of *Nuclear Power Generation* taken up by these nine authors with a cumulative professional nuclear-related experience of over 300 years.

Previous generations of Nuclear Reactors built in the U.S. were criticized for the costs, time taken, and security concerns. All of these factors were instrumental in stalling the pace of construction of nuclear reactors in this country. Self-assessment by owners, regulators, and consultants with the help of professional organizations such as ASME has largely addressed several or most of the items, so that if we were to build nuclear reactors, we are much wiser now than ever before. Several of the issues are technical, whereas some are pseudo-management issues. The authors in Chapters 21 through 24 of this Section VI succinctly chronicle the items for helping the future generation of reactors that will be built. Technological advances such as 3-D FEA methods, alloy metals used in the construction, and several other factors have made it possible by even a slight reduction in safety factors without reconciling the safety concerns; likewise, thinking process on the lines of pre-designed and modular constructions has alleviated the time from the initiation through the construction stages up to the completion of a nuclear reactor; the regulatory perspective has also gone beyond the U.S. bounds to countries that use the ASME Stamp of Approval for their Nuclear installations.

The future of the nuclear industry holds immense promise based on strides made in the U.S., Europe, and Asia. ASME Codes and Standards are used globally in building Nuclear Reactors. A discussion about Nuclear Power Generation is never complete without an understanding about the country's energy regulatory structure and decision-making process. In the first chapter of this section, Chapter 21, *A Perspective of Lessons Learned*, has been addressed by an author with several decades of experience in the U.S. nuclear industry. Hopefully this could be useful in building new reactors.

In Chapter 22, two experts with nuclear background provide a critical review of the "Nuclear Power Industry Response to Materials Degradation" problems, especially as it relates to the new plants. Authors discuss the fleet-wide recognition of these issues.

Experts from Switzerland, Idaho National Laboratories, General Electric, and Japan Nuclear Safety with knowledge of the next generation of nuclear reactors have contributed Chapter 23 summarizing global efforts. Authors provided an assessment of the existing generation and potential for new projects. These recognized experts with several decades of professional and Code experience have addressed the ramifications of the past and current constructions while providing their perspectives for the next generation of nuclear reactors.

An ASME Code expert succinctly addresses in the last chapter of Section VI (Chapter 24) the future of nuclear reactors that seems to be at the crossroads. It is most appropriate that the author provides an open window to look at the current concerns, future challenges, and most importantly the unfinished business to revive nuclear power generation in the U.S.

Recent events such as at the *Fukushima Daiichi Nuclear Plants* at Japan devastated by the Tohoku-Taiheiyu-Okai Earthquake and Tsunami of March 11, 2011 have not been addressed by the authors, since these require a separate treatment and will distract from the main theme of discussions.

Section VII is titled *Steam Turbines and Generators* and has two chapters, Chapters 25 and 26, authored by two industry experts in 52 pages. Interdependency of all the energy sources needs to be addressed, especially as it relates to energy sources that are intermittent, and this has been done in Section VII.

In Section VII, Chapters 25 and 26 will be dedicated to *Turbines and Generators*, since they are a crucial and integral part

of power generation, especially as they relate to Wind, Solar, Fossil, and Nuclear Power Generation. Discussions pertain to types of Turbine Configurations, their design, performance, operation, and maintenance. Turbine components, disks, and rotors including non-destructive methods have been covered in the discussions. In Chapter 25, the author discusses generators and crucial components such as retaining rings and failures. Material properties are briefly addressed. In both Chapters 24 and 25, the authors dwell upon the advanced technology and next generation of turbines.

In Section VIII of the book, Selected Energy Generation Topics have been covered in Chapters 27 through 30 in 79 pages. Topics selected for this Section stem from the importance of the topics for Renewable as well as Non-Renewable Energy Generation. The topics include Combined Cycle Power Plants, A Case Study, Heat Exchangers, and Water Cooled Steam Surface Condensers.

A recognized authority in *Combined Cycle Power Plants* with a Handbook on the subject has authored Chapter 27 that covers gas and steam turbines. The author has addressed the availability, reliability, and continuity of energy and power by using the combined cycle power plants.

In Chapter 28, *Hydro Tasmania—King Island Case Study* has been authored by three professional engineers of Hydro Tasmania, Australia, who address the renewable energy integration project. The discussions cover benefits including the development project.

Heat Exchangers are crucial components of Power Generation discussed in Chapter 29 by two recognized authorities with several decades of professional experience. The discussions rally around design aspects, performance parameters, and structural integrity.

A well-recognized authority in nuclear industry with global experience has authored the role of *Water Cooled Steam Surface Condensers* in Chapter 30. The author has covered design aspects, the construction details, and the related topics with schematics and a technical discussion with the help of 55 equations.

Whereas the *preceding groups* can be considered as the "core" of the book, the future of energy sources cannot be overlooked. Indeed, ignorance cannot be considered bliss in overlooking the energy and power generation potentials of the world. Ultimately, this planet's very existence depends on augmenting the energy and power generation resources. This could also imply conservation of energy (also covered in several of the preceding chapters) and harnessing methods that could improve known techniques.

In the last section of this handbook (Section IX), Emerging Energy Technologies have been addressed in 36 pages, in two chapters, by six authors. Use of untapped energy sources and peripheral items such as *Conservation Techniques, Energy Applications, Efficiency, and suggestions for Energy Savings "inside the fence"* is worthy of consideration.

In pursuit of the above statements, Chapter 31, *Toward Energy Efficient Manufacturing Enterprises*, has been addressed by two authors from the U.S. government, an expert from industry and an author from academia. Energy efficiency is implied in conservation and saving of energy, and this has been dealt with by authors in this chapter.

The cutting edge of technology by the use of *Nano-Materials and Nano Coatings* has been dealt with in Chapter 32 by two authors from academia. These experts deal in this chapter the use of Nano Technology in Fuel Cells, Wind Energy, Turbines, Nano-