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Power and Energy Systems Engineering Economics

Best Practice Manual

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Preface

The book's overall objective is to provide a comprehensive but concise coverage of engineering economics required for techno-economic evaluation of investments in energy business projects. Throughout the book the emphasis is on transferring practical know-how rather than pure theoretical knowledge, avoiding the detail of voluminous reference texts as needed by experts in specific fields. This is also demonstrated in numerous application examples and case studies derived from experience of respective projects. These also are available as softcopies on my website to help practice the contents of the book. Due to the very close link between engineering and economics and the concise outline the book is suitable for engineers as well as for economists and lawyers.

The book is neither a scientific paper nor literature research. In writing this book I have drawn from my knowledge of over 35 years' experience as a consultant in engineering and power economics for energy business projects worldwide and from numerous training courses I delivered for junior utilities' staff in several countries.

My aim after my retirement is to make my knowledge and experience available in practice oriented books. Target audiences of the book are primarily international consultants, staff members of engineering companies, utility personnel and energy economists and lawyers, as well as employees of government agencies entrusted with regulating the energy and utility sector and finally, students in related fields of engineering and economics.

I am a non-native English speaker; however, I wrote the book directly in English because in my opinion, it is the most proper language for the field of economics among others as most techno-economic terms are available in English only. I ask native speakers for their understanding for any linguistic shortcomings.

Comments and recommendations for improvements from readers are highly appreciated and will be thankfully considered in forthcoming editions of this book.

Burgstetten, Germany, October 2017 Panos Konstantin

Acknowledgments

The book mainly reflects the knowledge I have acquired and further developed from over 35 years' experience working for **Fichtner GmbH & Co. KG** in Stuttgart, Germany as a consultant and trainer for energy business projects worldwide. I am particularly thankful for their support and the opportunity to have access to their technical and human resources during my employment and beyond.

I am also grateful to many of my Fichtner colleagues as well as friends and clients for their advice and contribution to the development of this book.

Many thanks are also due to the colleagues of **HelpDesk Görlitz GmbH**, Germany for their help in properly formatting the book.

I am grateful to Markus Groissböck, who has developed and maintains my Website, and to Timo Dimitriades, who designs the covers of my books.

Many thanks to Amy Gooderum, an English teacher in the States, for proofreading and linguistic revisions of the book's text, and also for her numerous proposals to make the book's text better understandable also for readers, who are less familiar with parts of the contents.

Last but not least, I wish to thank Maggie Konstantin, my wife, for her support in editorial design and a second proofreading of the book's text and for her understanding for the long hours and evenings I have been spending in front of the computer.

All my professional life as a consultant, I wrote hundreds of reports for projects and attained a certain routine in writing. I have furthermore greatly benefited from the experience in writing my book "Praxisbuch **Energiewirtschaft",**[1] first published by Springer in 2006 and now available in its 4th edition since January 2017 by SpringerVieweg.

Finally, I like to announce my second book of the series "Best Practice manual" with the title:

"**The Power Supply Industry** – Technologies, Economics and Trading".

[1] In English: "Practice Oriented Book on Energy Economy"

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1 Introduction and Scope

1.1 Brief Outline of the Chapters

Chapter 1 provides a brief synopsis of the chapters. Throughout the book, the emphasis is on the transfer of practical know-how rather than pure theoretical knowledge. This is also demonstrated in numerous examples and case studies derived from experience in related projects.

Chapter 2 provides the necessary knowledge in financial mathematics deemed to be an indispensable prerequisite for the proper application of methods for appraisal and financial evaluation of investments.

Chapter 3 deals with key financial parameters which are essential for the evaluation of capital investments in particular: inflation, interest and the cost of capital. This chapter explains how to properly handle these parameters in financial evaluations of projects. Financial operations in *nominal terms* or in *real terms* are presented and practiced in examples.

The subject of **Chapter 4** is the appraisal of investment projects with regard to their profitability and/or cost effectiveness. Focus is given to the presentation and application of the methods Net Present Value (NPV), Internal Rate of Return (IRR) and Annuities.

Chapter 5 deals with project analysis models applied in bankable feasibility studies namely Financial, Economic and Benefit-Costs analysis. The methods are often confused with one another; the chapter highlights the different approaches and objectives and addresses different points of view.

Chapter 6 provides an introduction on cost allocation methods for cogeneration products heat and electricity.

Chapter 7 discusses methods for project risk assessment and mitigation. It addresses in particular sensitivity and scenario analysis, SWOT analysis, probability distribution and exceedance probability. Focus is given to inclusion of project and country risks in the discount rate (WACC).

Chapter 8 focuses on price-setting mechanisms and price development of the main fuels used for power generation, and also includes different approaches for the inclusion of price trends and forecasts in project evaluation.

In the final **chapter 9** seven case studies, derived from real projects, are presented, analyzed and discussed.

P. Konstantin and M. Konstantin, *Power and Energy Systems Engineering Economics*, https://doi.org/10.1007/978-3-319-72383-9_1

Important notes on the chapters

Examples: All chapters contain numerous practical application examples. The examples as well as the case studies are intended to practice the contents of the book only and are not applicable for commercial use.

Download examples: www.pk-energy-practical-knowhow.com

Almost all examples are developed in MS-Excel® spreadsheets and inserted into the text as pictures. We tried to keep them relatively simple; nevertheless, it is not always easy to retrace the calculation steps because they often include complex calculation formulas. However, it is not possible to include these in the examples depicted in the chapters due to limited space. Readers have the opportunity to download softcopies of the examples from my website above.

Currencies: The book is written for an international audience in countries with different currencies. In formulas which are generally applicable, the term "CU" (Currency Unit) is used. In application examples which are mainly derived from projects, either € (Euro) or US$ are used, depending on the origin of the projects. The real origin of the projects, however, is not disclosed.

Unit system: Throughout the book, the *Standard International Unit System* is used (based on MKS system: Meter, Kilogram, Second). This system is based on physics, includes only a few *base units*, and all the other units are derived from the base units. The units are easy to handle in calculations without the need for conversions. In the European Union, its use is obligatory for public projects and in most countries it is the standard unit system.

Heating values: For energy balances, price references etc. the lower heating values (*LHV*) are used (also referred to in literature as net calorific values - *NCV* or inferior heating value - *Hi*). Worth mentioning is that natural gas is commonly traded based on its *HHV* and is to be converted in *LHV* for calculations and energy balances.

1.2 Annexes

Annex 1 provides a brief description of *The Standard International Unit System* (metric system) that is used throughout the book. We recommend that users of the book read this outline for a better understanding of the calculations in the examples.

Annex 2 includes a conversion table for units and combined unit expression as US$/MMBTU to US$/GJ, etc.

Annex 3 includes a table with the properties of the main fuels used in power generation (heating values, CO_2 production).

Annex 4 presents a list of the functions and formulas used in the examples including their syntax and some help for the users.

Annex 5 presents Add-Ins for escalating series of payments developed by the author.

1.3 Glossary

This glossary contains definitions of techno-economic terms used in this book and some related terms that are of interest to the readers. The glossary consists of the following main parts:

- Most frequently used terms, arranged according to their importance and meaning, not in alphabetical order
- Some costs functions
- Most frequently used operational terms
- Terms in alphabetical order
- Deviations from customary definition of terms

Most of the terms are accompanied by units (e.g. kg/s, kWh/a, $/a, $/kWh) as it is a standard for engineers.

Please note that the terms are defined as used by the power and energy industry, and are not generally applicable for other sectors.

Several terms intentionally deviate from the pure economist's or accountant's terminology whenever we deem this to be appropriate. For example, we use the term "capital expenditures (CAPEX)" instead of investment costs, "operation expenses (OPEX)" instead of operation costs, "payment series" instead of cash flows. Please refer

to glossary item "Deviations from customary definitions" for an explanation of the divergence.

2 Financial Mathematics

2.1 Synopsis of the Chapter

This chapter provides the necessary knowledge in financial mathematics which is an indispensable prerequisite for the proper application of methods of appraisal and financial evaluation of investments.

The chapter starts with an introduction regarding the time value of money. In financial mathematics, values depend not only on their *face amount* but also on the time at which they are due. This is because money can earn accumulated interest during the time it is invested. On the contrary, the basic operations in classical mathematics do not take into account a time component in determining the value of amounts.

The operations associated with the time value of money are compounding and discounting. Software tools such as MS-Excel® provide some functions for the calculation of time values; however, users often have only a limited knowledge of the background of these functions. This may result in their incorrect application, especially if their use deviates from the standard. Therefore, the analytic algorithms of these functions are presented in this chapter and then special focus is given to their proper application.

In the following, the mathematical structure for compounding and discounting of single payments as well as a series of uniform payments, which are common for financial applications is presented. Beyond this, particular attention is given to escalating series of payments. For these, specific algorithms and software tools have been developed that allow for the computation of their present and levelized values. To our knowledge, these are available neither in literature nor in commercial software tools.

The chapter also includes numerous practical application examples for a better understanding and strengthening of the presented content.

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