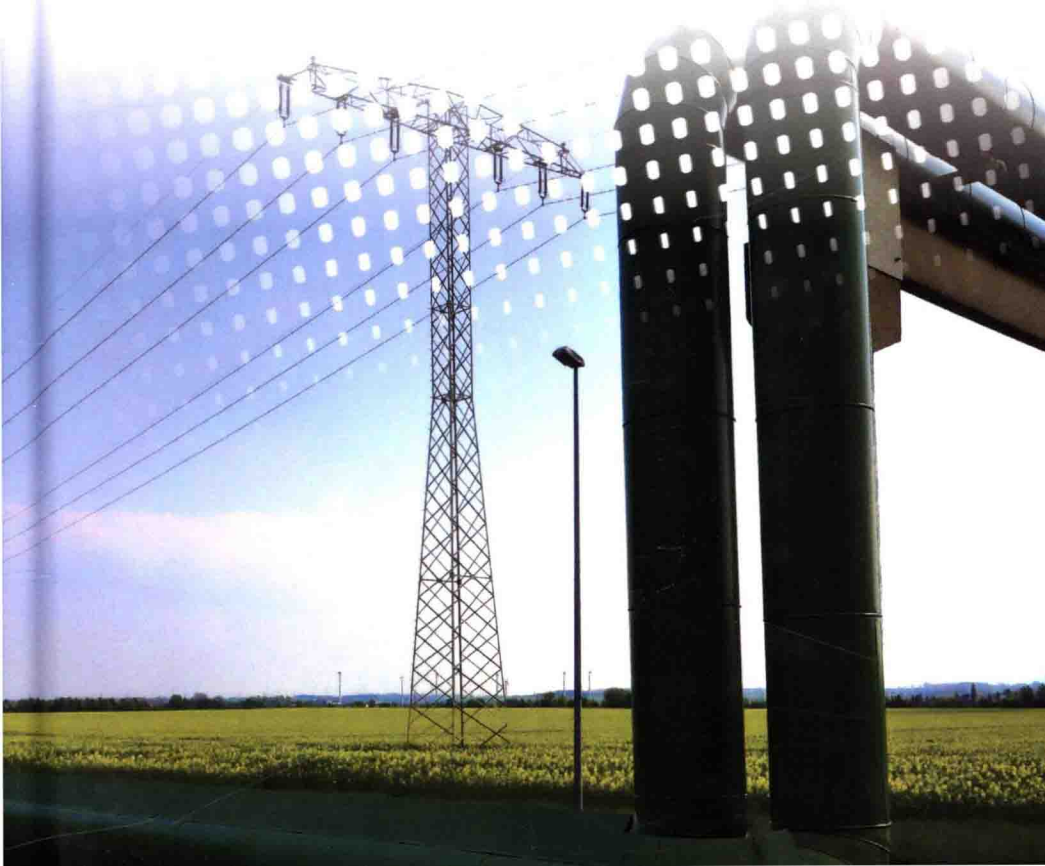
The Institution of Engineering and Technology

Cogeneration

Technologies, Optimisation and Implementation

Edited by
Christos A. Frangopoulos



Cogeneration

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Cogeneration, also called combined heat and power (CHP), refers to the use of a power station to deliver two or more useful forms of energy, for example, to generate electricity and heat at the same time. All conventional, fuel-based plants generate heat as by-product, which is often carried away and wasted. Cogeneration captures part of this heat for delivery to consumers and is thus a thermodynamically efficient use of fuel, and contributes to reduction of carbon emissions. This book provides an integrated treatment of cogeneration, including a tour of the available technologies and their features, and how these systems can be analysed and optimised.

Topics covered include benefits of cogeneration; cogeneration technologies; electrical engineering aspects; applications of cogeneration; fuels for cogeneration systems; thermodynamic analysis; environmental impacts of cogeneration; reliability and availability; economic analysis of cogeneration systems; regulatory and legal frameworks; selection, integration and operation of cogeneration systems; simulation and optimisation; synthesis, design and operation; examples of cogeneration projects; research and development of cogeneration; summary and conclusions.

This book is intended for instructors and students at advanced undergraduate as well as graduate level, for professional engineers who design, build and operate cogeneration systems, and for researchers on analysis and optimisation of energy systems.

About the Editor

Christos A. Frangopoulos is a Professor Emeritus at the School of Naval Architecture and Marine Engineering of the National Technical University of Athens (NTUA), Greece. His research focuses on the development and application of methods for analysis, evaluation and optimisation of synthesis, design and operation of energy systems (including cogeneration systems), by combining thermodynamic, economic and environmental considerations. He has lectured extensively on cogeneration. He is a member of the editorial boards of several scientific journals related to energy.

ISBN 978-1-78561-055-4

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Energy Engineering

The Institution of Engineering and Technology • www.theiet.org
978-1-78561-055-4

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Published by The Institution of Engineering and Technology, London, United Kingdom

The Institution of Engineering and Technology is registered as a Charity in England & Wales (no. 211014) and Scotland (no. SC038698).

First published 2017

The Institution of Engineering and Technology
Michael Faraday House
Six Hills Way, Stevenage
Herts, SG1 2AY, United Kingdom

www.theiet.org

British Library Cataloguing in Publication Data
A catalogue record for this product is available from the British Library

ISBN 978-1-78561-055-4 (hardback)
ISBN 978-1-78561-056-1 (PDF)

Typeset in India by MPS Limited
Printed in the UK by CPI Group (UK) Ltd, Croydon

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Preface

Cogeneration of electricity and heat was initiated in 1880–1890 and soon reached a level that most of the electricity needed in the industrial sector at least in the United States of America in the early 1900s was supplied by cogeneration systems. After several decades of decline, the interest and the investments in research, development and applications of cogeneration were revitalised in the 1970s, when it was realised that rejecting more than 50% of the energy contained in fuels burned in power plants to the environment in the form of heat, with no utilisation, was disastrous for both the depletion of non-renewable energy resources and the negative effects on the environment.

During the 40 years that followed, cogeneration technology has reached maturity, and several books on the subject have been published. So, the reader may wonder what one more book could add to the related body of knowledge. It is important to note that cogeneration has many aspects: technical, economic, financial, environmental and legal. All these aspects are treated in the available bibliography, but an integrated treatment that shows how they are interweaved was still missing. Furthermore, the design and operation has been addressed with a conventional approach based on common experience and comparison with alterative options. However, such a treatment may not lead to the technically and economically best system, due to the complexity of cogeneration systems and the fact that conditions, such as loads and the tariff systems, change with time. Instead, the formal application of mathematical optimisation at three levels (synthesis, design specifications and operation) is proposed and presented here.

The book is intended for instructors and students at advanced undergraduate as well as graduate level, for professional engineers who design, build and operate cogeneration systems, and for researchers on analysis and optimisation of energy systems. Fundamental knowledge of Engineering Thermodynamics is necessary for better understanding of the analysis of the systems, whereas knowledge of optimisation techniques is necessary for better understanding of the related chapter and for applying optimisation on cogeneration systems.

I would like to thank the Institution of Engineering and Technology, UK, for inviting me to act as the editor of the book, and its personnel for supporting me throughout this endeavour.

Many thanks are due to all the authors of the various chapters, who accepted the invitation to contribute to the book. Without their cooperation, it would be impossible to present so many diverse aspects of cogeneration.

Special thanks are due to Dr. Jacob Klimstra, who joined the effort since the beginning and had a crucial role not only in writing and reviewing several chapters, but also in contributing to the development of the whole content of the book.

Also, I take the opportunity to thank all my collaborators in projects related to research and promotion of cogeneration, as well as the members of legislative committees I participated in, who helped me not only in completing the tasks successfully, but also in better understanding cogeneration and its complexities.

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October 2016

Short biographies

Editor and author

Christos A. Frangopoulos is a Professor Emeritus at the School of Naval Architecture and Marine Engineering of the National Technical University of Athens (NTUA), Greece. His research focuses on the development and application of methods for analysis, evaluation and optimisation of synthesis, design and operation of energy systems (including cogeneration systems), by combining thermodynamic, economic and environmental considerations. He has lectured extensively on cogeneration. He is a member of the editorial boards of several scientific journals related to energy.

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Lucyna Czarnowska is an Assistant Professor at Silesian University of Technology since 2014. She has an extensive experience in thermo-ecological cost, cumulative energy and exergy, dispersion of pollutants in the air and external environmental cost. She focuses on CO_2 emission from power plants, refinery and cement industry. Currently, she is involved in two projects, which are funded by Norway Grants in the Polish-Norwegian Research Programme. Moreover, she is an academic teacher of environmental impact and thermoeconomic evaluation in energy sector.

Jacob Klimstra (Ph.D.) worked at Gasunie Research in Groningen, NL, on all aspects of the gas transport and supply chain, including reciprocating engine optimisation and cogeneration of electricity and heat. He was also the Head of Department of Industrial Gas Applications at Gasunie Research. Subsequently, he was employed by Wärtsilä Power Plants, as senior specialist on energy issues and engine-driven power systems. Currently, he works as a consultant (www.klimstra.nl). He wrote many papers about energy use and electricity production and frequently gives presentations.

Mats Östman is currently working as a Senior Development Manager in Wärtsilä Energy Solutions, renewables and storage business line, where he is responsible for development activities, related to concepts and systems within the electrical engineering discipline. He graduated in Vaasa, Finland, with a Bachelor's degree in electrical engineering. He joined Wärtsilä in 1995, currently focusing on energy storage and grid connection related topics.

Wojciech Stanek was graduated from Silesian University of Technology in 1994. In 1998, he obtained Ph.D. degree and in 2009 D.Sc. degree. In 2011, he was awarded by Polish Academy of Sciences for Excellent D.Sc. Thesis. He is an Associate Professor at the Silesian University of Technology. Fields of his interests are power and cogeneration plants, mathematical modelling of energy management in power sector and industrial plants, advanced exergy analysis and ecological assessment of production processes by means of exergy analysis.

Costas G. Theofylaktos is a Senior Energy Expert, with BSc and MSc in Mechanical Engineering from the University of Evansville, Ind., USA. In his 30-year career, he has managed and carried out several projects in energy policy, energy economics and management, energy measurements and audits in Cogeneration of Heat and Power and District Heating Systems, working with international institutions such as EU, EBRD, WB and others. He served as COGEN EUROPE's Executive Committee member and as President of the Hellenic Association for CHP.

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