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Micro Cogeneration

Towards Decentralized Energy Systems

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Contents

Contents V

Introduction..... XI

1 Micro Cogeneration Technology 1

 1.1 Defining Micro Cogeneration..... 1

 1.2 Conversion Technologies 3

 1.2.1 Reciprocating Engines..... 4

 1.2.2 Stirling Engines 7

 1.2.3 Fuel Cells..... 9

 1.2.4 Other Technologies 11

 1.3 Grid Integration, Communication Technology, and Virtual Power
Plants 13

 1.4 Summary of Technologies..... 16

**2 Dynamics of Socio-Technical Change: Micro Cogeneration in
Energy System Transformation Scenarios 19**

 2.1 Introduction 19

 2.2 Driving and Embedded: Micro Cogeneration and the Dynamics
of Socio-Technical Change 22

 2.3 Pluralism of Prophecies: Scenarios of Transformation in
Electricity Systems 27

 2.3.1 Types of Energy Scenarios..... 29

 2.3.2 Forecasting 29

 2.3.3 Technology Foresight..... 32

 2.3.4 Policy Scenarios 35

 2.3.5 Explorative Scenarios..... 40

 2.4 Conclusions 45

**3 The Future Heating Market and the Potential for Micro
Cogeneration 49**

 3.1 Current Situation of Micro Cogeneration in Germany 50

 3.2 Demand Drivers in the Heat Market..... 51

 3.3 The Technical Micro Cogeneration Potential: Scenarios for
Germany 57

 3.3.1 Future Heat Demand in the Residential Sector 58

3.3.2 Future Heating Supply in the Residential Sector.....	61
4 Economics of Micro Cogeneration	67
4.1 Micro Cogeneration Technologies	68
4.2 Reference Buildings	69
4.3 Heat and Electricity Supply Scenarios	71
4.4 Economic Parameters	72
4.4.1 Energy Prices and Subsidies.....	72
4.4.2 Economic Losses or Benefits for Distribution Network Operators	74
4.4.3 Economic Perspectives of Different Operators	74
4.5 Micro Cogeneration Electricity Generation Costs.....	77
4.6 Economic Performance of Micro Cogeneration in Different Buildings	80
4.6.1 Independent Operators' Perspective.....	80
4.6.2 Perspective of Vertically Integrated Utilities	82
4.6.3 Societal Perspective.....	83
4.7 Conclusions	85
5 Environmental Impacts of Micro Cogeneration	87
5.1 Life Cycle Assessment of Micro Cogeneration.....	88
5.1.1 Considering the Co-product	89
5.1.2 Input Data for Micro Cogeneration Systems, Fuels, and Conventional Power Plants	92
5.1.3 Impact Assessment	95
5.2 Results of the Life Cycle Assessment	95
5.2.1 Greenhouse Gas Emission Reduction of Natural Gas Micro Cogeneration	95
5.2.2 Pollutant Emissions	98
5.2.3 Local Impacts from Air Pollutant Releases.....	101
5.2.5 From Gas to Renewables: Other Micro Cogeneration Fuels	107
5.3 Beyond the Single Micro Cogeneration Unit	109
5.3.1 Avoided Grid Losses	109
5.3.2 Connecting Micro Cogeneration to Create Virtual Power Plants	110
5.3.3 Indirect Ecological Impacts through User Behavior	111
5.4 Conclusions	114
6 From Consumers to Operators: the Role of Micro Cogeneration Users.....	117

6.1 Data and Literature	119
6.2 Socio-demographic Characteristics	123
6.3 Attitudes	126
6.3.1 Political Attitudes	126
6.3.2 Technology Attitudes	127
6.3.3 Environmental and Energy Attitudes	128
6.3.4 Conclusions on Attitudes.....	132
6.4 Motives, Goals, and Interests	133
6.4.1 Reasons for Considering Fuel Cell Micro Cogeneration...	133
6.4.2 Requirements for Home Energy Supply.....	134
6.4.3 Micro Cogeneration Technologies in Comparison.....	137
6.5 The Pioneers as Multipliers	139
6.6 Uncertainty as a Barrier	140
6.7 Summary and Conclusions: Pioneers for Promoting Micro Cogeneration.....	141
7 Micro Cogeneration – Setting of an Emerging Market.....	145
7.1 A Changing Environment for Micro Cogeneration	146
7.1.1 Energy Prices.....	148
7.1.2 The Electricity Market.....	149
7.1.3 The Gas Market	152
7.1.4 Tackling High Transaction Costs and Small Margins.....	153
7.2 The Actor’s Perspective: Strategy, Motivation and Institutions	156
7.2.1 Technology Developers.....	157
7.2.2 Gas Supply Industry	159
7.2.3 Large Electricity Companies	160
7.2.4 Local Energy Companies	162
7.2.5 Customers	163
7.2.6 Energy Contracting and Service Companies	164
7.2.7 Distribution Network Operators	165
7.3 Incentives and Disincentives for Micro Cogeneration	167
8 Institutional Framework and Innovation Policy for Micro Cogeneration in Germany.....	171
8.1 Institutional Structures.....	172
8.1.1 Liberalization of Electricity Markets and Grid Access	172
8.1.2 Energy Taxation	177
8.1.3 Combined Heat and Power Law	178
8.1.4 European CHP Directive	181
8.1.5 Energy-Saving Decree.....	183
8.1.6 Emissions Trading.....	184
8.1.7 Local Air-Emissions Standards	186

8.1.8 Institutional Barriers	186
8.1.9 Institutional Framework: Discrepancy Between Formal Rules and Actual Effects	188
8.2 Innovation Policy.....	190
8.2.1 Status of Micro Cogeneration in Policy Strategies.....	191
8.2.2 Research and Development	191
8.2.3 Investment Subsidies for Energy Efficiency	192
8.2.4 Promotional Networks.....	193
8.2.5 Informational Measures.....	194
8.2.6 Innovation Policy: Overshadowed by Large CHP, Outshone by Fuel Cells.....	195
9 Embedding Micro Cogeneration in the Energy Supply System	197
9.1 Challenges to Security of Energy Supply	197
9.2 Potential Impacts of Micro Cogeneration.....	200
9.3 Embedding Micro Cogeneration in the Electricity Network	202
9.3.1 Equipment Capacity	203
9.3.2 Voltage Variations.....	205
9.3.3 Protection Issues.....	207
9.3.4 Voltage and Current Transients.....	207
9.3.5 Transmission and Distribution Losses.....	208
9.3.6 Ancillary Services and Impacts on Peak Loads.....	208
9.4 Perspectives for Using Renewable Fuels.....	212
9.5 Conclusions	216
10 The Micro Cogeneration Operator: A Report from Practical Experience	219
10.1 Starting Situation	219
10.2 Options of Operating a Micro Cogeneration Unit	223
10.3 Practical Experiences with the Concrete Operation of Micro Cogeneration.....	224
10.4 Practical Experiences with the Regulatory Framework.....	226
10.5 Public Acceptance	229
10.6 Conclusions	229
11 Micro Cogeneration in North America.....	231
11.1 Micro Cogeneration Status in North America	231
11.1.1 Previous Attempts to Develop Micro Cogeneration.....	232
11.1.2 The Market Today	233
11.1.3 U.S. Department of Energy Action	233
11.2 Framework for Micro Cogeneration.....	234

11.2.1 Heating and Cooling Markets.....	234
11.2.2 Electricity Industry	235
11.3 Micro Cogeneration Policy and Incentives.....	236
11.3.1 U.S. Department of Energy Micro Cogeneration Policy.....	236
11.3.2 Solid State Energy Conversion Alliance	237
11.3.3 U.S. Cogeneration Policy	237
11.3.4 Net Metering.....	239
11.3.5 State-level Incentives.....	239
11.4 Development of Micro Cogeneration Products in the U.S.	241
11.5 Conclusions	242
12 Micro Cogeneration in Britain	243
12.1 Political and Economic Framework.....	243
12.1.1 UK Energy Policy.....	243
12.1.2 Implementation of Policy	246
12.1.3 Support Measures	246
12.1.4 Independent Bodies and Lobbying Activity	248
12.1.5 Current Issues	248
12.1.6 Legislation and Regulation.....	249
12.1.7 Energy Prices.....	250
12.2 Market Context.....	251
12.2.1 Housing Stock and Energy Use.....	251
12.2.2 Climate	252
12.2.3 Heating Systems	253
12.2.4 Boiler Market.....	253
12.2.5 Technology Developments	254
12.3 Major Commercial Activities and Actors in the Country.....	259
12.3.1 UK Energy Industry Structure.....	259
12.3.2 Routes to Market	260
12.3.3 Market Status.....	261
13 Micro Cogeneration in Japan	265
13.1 The Energy Situation of Japan.....	265
13.1.1 Primary Energy Supply and Power Generation.....	265
13.1.2 Electric and Gas Utilities.....	267
13.1.3 Energy Market Deregulation	267
13.2 The Reciprocating Engine Micro Cogeneration Market in Japan.....	268
13.2.1 Micro Cogeneration for Commercial Use	269
13.2.2 Micro Cogeneration for Residential Use	270
13.2.3 Development Initiatives.....	272
13.2.4 Prospects for Gas Engine Micro Cogeneration in Japan ..	273

13.3 Fuel Cell Development.....	273
13.4 Conclusions	275
14 Micro Cogeneration in the Netherlands	277
14.1 Introduction	277
14.2 Potential.....	277
14.3.1 Micro Cogeneration Developers in the Market	279
14.3.2 Micro Cogeneration Developers Trialling.....	280
14.3.3 Other Developers.....	281
14.3.4 Manufacturers.....	281
14.3.5 Gasunie.....	282
14.3.6 Electricity Utilities	283
14.4 Projects	284
14.5 Government Actions.....	284
14.5.1 Energy Transition	285
14.5.2 Eco Innovation	285
14.6 Regulations.....	286
14.6.1 Right to Connect.....	286
14.6.2 Fit & Inform	287
14.6.3 Meter Changes.....	287
14.6.4 Feed-In Tariff	288
14.6.5 Certification.....	288
14.7 Expectations	289
15 Summary and Conclusions	291
15.1 Towards a Decentralized Energy Supply: Summary.....	291
15.2 International Experience.....	299
15.3 Conclusions	304
16 References, Links, Authors and Abbreviations	311
16.1 References	311
16.2 Internet Links.....	329
16.3 The Authors	333
16.4 Abbreviations	340

Introduction

The electricity systems of many countries are currently undergoing a process of transformation. Market liberalization has induced major mergers and acquisitions in the electricity sector, but has also forced companies to seek out new business areas. Environmental regulations, like the Kyoto process and the European Emissions Trading Scheme, are exposing the sector to external pressure. New technologies – such as renewable energy, combined heat and power (CHP), or “clean coal” technologies – are emerging. Recent worldwide experiences with blackouts have once more put security of supply on the agenda. In Germany, the nuclear phase-out and decommissioning of outdated coal plants will lead to a need for replacement of more than one third of the current generation capacity by 2020.

The need for replacement is an extremely important driving force for the current transformation, forcing conventional and new technologies to compete for a role in the future energy supply. The overall transformation of electricity systems is neither driven nor shaped by technical or societal modifications alone, but rather by a rich diversity of processes in the realms of technology, politics, society and economy.

Achieving sustainable development in the energy sector entails specific qualities characterizing the changes which need to be undertaken. Climate change and limited fossil resources call for a reduction of non-renewable primary energy input and greenhouse gas (GHG) emissions by 50 to 80 % by 2050 (Enquête 2002). The resulting structural transformation will require innovation in many different realms, including the development of new technologies, new forms of corporate organization, new user routines, new institutional arrangements for governance, new conceptions regarding how problems should be understood, and new means of measuring electricity system performance.

One possible developmental path is decentralization of the electricity system. Distributed power generation in small, decentralized units is expected to help in reducing emissions and saving grid capacity, while also providing opportunities for renewable energy. It could thus form a constituent part of a more sustainable future. Broad implementation of

distributed generation, however, would imply thoroughgoing structural change as well as a surge in innovation.

Recently, decentralization and developing means for autonomous or individual energy supply also appear to be *en vogue*. A trend towards smaller technical systems has, since the 1970s, been advocated by many writers as a return to life on a human scale. The economist and writer E. F. Schumacher, for instance, wrote that technological development should be given “a direction that shall lead it back to the real needs of man, and that also means: *to the actual size of man*. Man is small, and, therefore, small is beautiful. To go for giantism is to go for self-destruction” (Schumacher 1973). This vision of decentralized, and often autonomous, technological systems has been often replicated and has also been applied to energy systems. For instance, in its 2002 memorandum the Club of Rome demanded that, whenever possible, a decentralized energy supply should be established (Club of Rome 2002). Visionary thinkers like Jeremy Rifkin have stated that, in the new age of decentralized energy production, everybody could, in principle, generate and consume his own energy (Rifkin 2002).

The present book focuses on one such element of distributed generation options which could play a role within the development of sustainable energy systems for the future, actually a micro-aspect within the overall transformations that are already going on and will be going on over the coming years. This is the combined production of electricity and heat in small units that are directly embedded in the buildings where the heat and electricity are to be used. This configuration is referred to as *micro cogeneration*.

Compared to the currently dominant pattern which combines electricity production in central plants, supplying 100,000 buildings at once, with separate on-site heating systems, micro cogeneration would make a fundamental difference in electricity systems if it actually became widely implemented. It not only integrates technological as well as cultural and institutional components, but also entails the potential for reducing the ecological impacts of electricity production. However, as many chapters in this book will seek to illustrate, the current context for micro cogeneration in many countries is not a very bright one.

Micro cogeneration thus offers a rewarding opportunity for studying the conditions facing radical innovations in potentially unfavorable regime contexts. At the same time, when market and economic factors become favorable, micro cogeneration may have the potential for reaching a considerable market size, thereby helping to advance other downstream or system innovations, such as the “virtual power plant” or new household energy-management systems, combined with altered consumer awareness.

More recently, the interest in micro cogeneration has also been fuelled by an enthusiastic interest in fuel cells, which could, amongst other applications, also be used in individual buildings as CHP devices. But micro cogeneration goes beyond fuel cell technology and involves various other conversion technologies.

This book aims at assessing the potential contribution of micro cogeneration towards a sustainable transformation of electricity systems. We examine the role it should or may play within a sustainable energy strategy, assess related implementation conditions and discuss possibilities to improve the context for introducing micro cogeneration on a larger scale. The issue demands a multifaceted answer that considers the various factors involved in real world applications of micro cogeneration. This book, therefore, combines the perspectives of engineering and life cycle studies, economics, sociology, applied psychology, and political science. Not only various academic disciplines, but also different national perspectives need to be taken into account, because the success chances of micro cogeneration largely depend on both the “hardware” and “software” of a country: on the one hand, the existing infrastructural context which micro cogeneration has to fit into (e.g., building stock, dominant fuels, district heating infrastructure) and, on the other hand, the political and economic framework, including support schemes, innovation policy, energy prices, and micro cogeneration legislation. Therefore, authors from several countries where significant micro cogeneration-related developments are now taking place were invited to contribute to this book.

Structure of the book. The core of this book is based on research carried out within a project called “Transformation and Innovation in Power Systems” (www.tips-project.de), funded by the German Ministry for Education and Research (*Bundesministerium für Bildung und Forschung, BMBF*), under the auspices of the Socio-Ecological Research Framework (*Sozial-ökologische Forschung*), launched in 2001.

Chap. 1 defines the book’s terrain: what is micro cogeneration? What are adequate conversion technologies? Which further technological components are required for establishing a functioning micro cogeneration system?

Micro cogeneration is part of a larger transformation process. In **Chap. 2**, we investigate the relevance of this process for the future performance of micro cogeneration and, vice versa, the role different kinds of energy scenarios attribute to micro cogeneration. In **Chap. 3**, we discuss important parameters which determine market perspectives for micro cogeneration, and try to assess the potential for it in the German market under different conditions.

How far this market potential is actually exploited depends primarily on the economic performance of micro cogeneration (**Chap. 4**). Here, we calculate its economic viability from different perspectives. Another prerequisite for successful market development is the environmental superiority of this innovation. Therefore, an environmental life cycle perspective on micro cogeneration is presented in **Chap. 5**.

Because micro cogeneration can be considered to be one of the most extreme examples of decentralization, the consumer gains in importance. Under certain circumstances, the boundary between consumer and producer is even blurred or eliminated. In **Chap. 6**, the users, particularly early pioneers who are necessary for spreading information about and realizing the systems, are the object of detailed description. Not only the consumers, but also energy companies are major actors involved in developing, or retarding, micro cogeneration development. **Chap. 7** looks at the setting of energy markets and entrepreneurial actors relevant to implementing micro cogeneration in Germany; it inquires about their interests, motivations, and strategies to foster, or to hold back, this innovative technology. The institutional framework of micro cogeneration in Germany involves not only directly CHP-related legislation, but also general energy legislation, innovation policy, and funding for research and development. **Chap. 8** tries to precisely locate the field on which micro cogeneration has to prove itself.

Successful development of micro cogeneration requires compatibility with existing and future energy systems. This concerns not only security of supply and availability of fuels, but also technical compatibility with electricity networks. This embedding of micro cogeneration is investigated in **Chap. 9**.

Whereas the TIPS study funded by the German ministry focused on micro cogeneration from an analytic point of view, the experiences of a micro cogeneration practitioner are described in **Chap. 10**, dealing with the various types of micro cogeneration operators and the range of the unforeseen problems occurring in the everyday operation of micro cogeneration.

Micro cogeneration is being developed, and in fact has been more successfully implemented, in other regions worldwide. We therefore invited micro cogeneration experts from the four most important micro cogeneration countries outside Germany – Great Britain, the Netherlands, Japan, and the United States of America – to report on micro cogeneration hard- and software, and the respective peculiarities in these countries (**Chap. 11 to 14**). Following our conclusions in **Chap. 15**, the reader is referred to a substantial body of literature and World Wide Web resources (**Chap. 16**).

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