

A FUNCTIONAL LEGAL DESIGN  
FOR RELIABLE ELECTRICITY SUPPLY

ENERGY & LAW SERIES

1. *European Energy Law Report I*, Martha M. Roggenkamp and Ulf Hammer (eds.)
2. *The Regulation of Power Exchanges in Europe*, Martha M. Roggenkamp and François Boisseleau (eds.)
3. *European Energy Law Report II*, Martha M. Roggenkamp and Ulf Hammer (eds.)
4. *European Energy Law Report III*, Ulf Hammer and Martha M. Roggenkamp (eds.)
5. *European Energy Law Report IV*, Ulf Hammer and Martha M. Roggenkamp (eds.)
6. *A Functional Legal Design for Reliable Electricity Supply*, Hamilcar Knops

A FUNCTIONAL LEGAL DESIGN  
FOR RELIABLE ELECTRICITY SUPPLY

HOW TECHNOLOGY AFFECTS LAW

HAMILCAR P.A. KNOPS



intersentia

Antwerp – Oxford – Portland

*Distribution for the UK:*  
Hart Publishing Ltd.  
16C Worcester Place  
Oxford OX1 2JW  
UK  
Tel: + 44 1865 51 75 30  
Fax: + 44 1865 51 07 10

*Distribution for the USA and Canada:*  
International Specialized Book Services  
920 NE 58th Ave Suite 300  
Portland, OR 97213  
USA  
Tel: +1 800 944 6190 (toll free)  
Tel: + 1 503 287 3093  
Fax: + 1 503 280 8832  
email: [info@isbs.com](mailto:info@isbs.com)

*Distribution for Switzerland  
and Germany:*  
Schulthess Verlag  
Zwingliplatz 2  
CH-8022 Zürich  
Switzerland  
Tel: + 41 1 251 93 36  
Fax: + 41 1 261 63 94

*Distribution for other countries:*  
Intersentia Publishers  
Groenstraat 31  
BE-2640 Mortsel  
Belgium  
Tel: + 32 3 680 15 50  
Fax: + 32 3 658 71 21

### **The Energy & Law Series**

The Energy & Law Series is published in parallel with the Dutch series *Energie & Recht*.  
Members of the editorial committee are:

Prof. Dr. Martha M. Roggenkamp, University of Groningen and Simmons & Simmons,  
Rotterdam (editor in chief)

Prof. Dr. Kurt Deketelaere, Institute of Environmental and Energy Law, University of Leuven

Prof. Dr. Leigh Hancker, Allen & Overy, Amsterdam, and Tilburg University

Dr. Tom Vanden Borre, Chief Counsellor, Commission for the Regulation of Electricity and  
Gas (CREG) and University of Leuven

A Functional Legal Design for Reliable Electricity Supply  
– How technology affects law  
Hamilcar P.A. Knops

© 2008 H.P.A. Knops  
Intersentia  
Antwerp – Oxford – Portland  
<http://www.intersentia.be>

ISBN 978-90-5095-780-9  
D/2008/7849/25  
NUR 828

No part of this book may be reproduced in any form, by print, photoprint, microfilm, or any other means, without written permission from the publisher.

## PREFACE

It all started with a simple idea: electricity is ‘different’ and how does that affect law? That brief thought turned out to be the start of an interesting journey through the world of energy and law. A journey on which I encountered many interesting topics, which brought me to many different places, and during which many people helped me.

This Ph.D. research was made possible through a grant of the Netherlands Organisation for Scientific Research (NWO). The research has been carried out as a joint project of Leiden University (Faculty of Law) and Delft University of Technology (Faculty of Technology, Policy and Management). In Leiden, the research was part of the research programme ‘Securing the rule of law in a world of multi-level jurisdiction’. In Delft, this study fits in the ‘Next Generation Infrastructures’ programme. Following the spirit of the *joint* project, this preface is written in accordance with the Leiden tradition, although the defence of this Ph.D. thesis takes place in Delft.

My first steps in energy law I made at the International Institute of Energy Law in Leiden. I am grateful to my colleagues of that time: Eugene Cross for introducing me into electricity law and Martha Roggenkamp for all the opportunities she has provided me over the years. Further I want to thank my colleagues of the *Europa Instituut* in Leiden.

After having studied in Leiden, Delft was a new environment to me. Fortunately, my nice colleagues of the Energy and Industry section made me feel at home there. Moreover, I would more specifically like to thank my ‘electricity colleagues’ Viren Ajodhia, François Boisseleau, Hanneke de Jong, Laurens de Vries and Ype Wijnia for being such a good interdisciplinary team and such good company at the various conferences. I am also grateful to Paulien Herder for introducing me to the world of engineering design. I also have to thank Anish Patil for always providing me the opportunity of some ‘transition’ from energy law to the laws of cricket.

Since 2005 I also work for the *Wetenschappelijk Instituut voor het CDA (WI)*. I am grateful for the way in which the WI facilitated my effort of completing this thesis. Moreover, the moral support I received from my colleagues has been invaluable.

This thesis has occupied me for quite some time. During the year 2007, the manuscript of the thesis has accompanied me virtually everywhere, so that my

journey-in-energy-law itself has completed its own journey around the world. In particular the last year I was so occupied with the thesis project that I could not pay as much attention to my friends as I would have liked to do. Now the thesis is done, it is time to catch up, I promise.

I should also thank my former and current *huisgenoten* (roommates) of the Morsweg. During all the years of my research our ‘Mors’ has remained my home. It has been nice to share our lives and to learn from each other. Two of them deserve special mention for their contribution to this thesis: Mark Dingemans for making most of the illustrations and Steven Tijms for helping me with a certain proposition. . .

As I wrote above, on my journey in the world of energy law I came across many challenging and topical questions in that field, many of which lie outside the scope of this thesis. As a side effect, this thesis waited a while for completion. Eventually, however, the original destination has been reached: the brief question of ‘how the technology of electricity affects law’ has finally resulted in this—elaborate—thesis. Completing this thesis would have been impossible without the support of my parents, upon whom I could count under all circumstances, and Catherine Chiong Meza, whose help with the transformation of—literally—a *manuscript* to an electronic document has been invaluable and who herself made me realise that there *is* a life after the Ph.D. thesis.

Hamilcar Knops  
December 2007

# TABLE OF CONTENTS

<b>Preface</b>	<b>v</b>
<b>Table of Contents</b>	<b>vii</b>
<b>List of Tables</b>	<b>xii</b>
<b>List of Figures</b>	<b>xiii</b>
<b>1 Electricity supply: from monopoly to complexity</b>	<b>1</b>
1.1 Introduction . . . . .	1
1.2 A paradigm shift for network industries . . . . .	2
1.3 What does it mean for electricity? . . . . .	7
1.4 Main research question . . . . .	10
1.5 Relevance . . . . .	18
1.6 Reading guide . . . . .	19
<b>2 Research framework</b>	<b>23</b>
2.1 Research goal . . . . .	23
2.2 Research question . . . . .	24
2.3 A design problem: the meta model . . . . .	30
2.4 The meta model as applied to this research question . . . . .	35
2.5 Research method . . . . .	38
<b>3 System description</b>	<b>43</b>
3.1 Introduction: the electricity system . . . . .	43
3.2 The technical subsystem . . . . .	44
3.2.1 The physical layer . . . . .	46
3.2.2 The operational layer . . . . .	50
3.3 The economic subsystem . . . . .	53
3.3.1 Three types of services . . . . .	54
3.3.2 The commodity market . . . . .	54
3.3.3 Technical services ('connection') . . . . .	56
3.3.4 Other services ('commercial') . . . . .	57
3.4 The subsystems integrated . . . . .	57
3.4.1 Links from the technical to the economic subsystem . . . . .	58

3.4.2	Links from the economic to the technical subsystem . . .	60
3.4.3	Transmission tariffs: ‘copper plate’ or not? . . . . .	62
<b>4</b>	<b>Legal organisation</b>	<b>65</b>
4.1	Introduction . . . . .	65
4.2	Hohfeld’s fundamental legal conceptions . . . . .	68
4.3	Policy instruments . . . . .	71
4.4	Legal organisation: the issues . . . . .	77
4.5	Allocation of responsibility . . . . .	80
4.6	Permissions: who is allowed to perform which tasks? . . . . .	82
4.7	Rules: how to perform responsibilities and permissions? . . . . .	84
4.8	Government control . . . . .	85
4.9	Design variables . . . . .	89
<b>5</b>	<b>Public policy goals</b>	<b>91</b>
5.1	Introduction . . . . .	91
5.2	Triple A: the main primary goals . . . . .	92
5.3	Availability: secure supply for all . . . . .	94
5.4	Affordability: the quest for economic efficiency . . . . .	97
5.5	Acceptability: socially responsible electricity supply . . . . .	100
5.6	Secondary goals . . . . .	102
5.7	The main goals in our design problem . . . . .	107
<b>6</b>	<b>Legal constraints</b>	<b>111</b>
6.1	Introduction: restriction to the EU . . . . .	111
6.2	Development of a European electricity framework . . . . .	113
6.3	Free movement of goods . . . . .	116
6.4	Free movement of services and capital and the right of establishment	125
6.5	Competition law: rules for undertakings . . . . .	130
6.6	State aid . . . . .	138
6.7	Public service obligations . . . . .	140
6.8	Directives: main structure of the industry . . . . .	153
6.9	Conclusion: legal constraints in our design problem . . . . .	158
<b>7</b>	<b>Design method</b>	<b>163</b>
7.1	A ‘method’ to integrate the model and selection stages . . . . .	163
7.2	Outline of the method . . . . .	166
7.3	Step I: Analysis of the function . . . . .	168
7.4	Step II: Analysis of each function within its context . . . . .	173
7.5	Step III: Design decisions for the legal organisation . . . . .	179
7.5.1	The core of the FULDA-method . . . . .	179
7.5.2	Who should decide about the organisation of a function? . . . . .	181
7.5.3	A. Should someone be made explicitly responsible for this function? . . . . .	184
7.5.4	B. Who should be made responsible? or: Who should be allowed to perform this function? . . . . .	186



7.5.5	C. How should the function be further organised? . . . . .	188
7.5.6	D. What control possibilities for government should be implemented? . . . . .	194
<b>8</b>	<b>An inventory of critical technical functions</b>	<b>209</b>
8.1	Introduction . . . . .	209
8.2	Building a functional model . . . . .	210
8.3	The functions . . . . .	213
8.4	Categorising the functions . . . . .	221
8.5	Selecting the functions for the case studies . . . . .	222
<b>9</b>	<b>Electricity generation</b>	<b>227</b>
9.1	Introduction . . . . .	227
9.2	Analysis of generation as a function (Step I) . . . . .	227
9.3	The function of generation in its context (Step II) . . . . .	229
9.4	Designing the organisation of generation (Step III) . . . . .	231
9.5	Conclusion: generation in a market environment . . . . .	235
<b>10</b>	<b>Maintenance of the energy balance</b>	<b>239</b>
10.1	Introduction . . . . .	239
10.2	The analysis of the function (Step I) . . . . .	239
10.3	The function within its context (Step II) . . . . .	246
10.4	Design of the function's organisation (Step III) . . . . .	250
10.5	Compensation of energy losses . . . . .	268
10.6	Conclusion and analysis . . . . .	273
<b>11</b>	<b>Generation adequacy</b>	<b>277</b>
11.1	Introduction . . . . .	277
11.2	Securing sufficient investment in generation capacity (Step I) . . . . .	277
11.3	Generation adequacy in its context (Step II) . . . . .	281
11.4	Designing a framework to secure generation adequacy (Step III) . . . . .	284
11.4.1	Should someone be made explicitly responsible? . . . . .	284
11.4.2	Who should be made explicitly responsible? . . . . .	285
11.4.3	Controlling the function through capacity mechanisms . . . . .	287
11.5	Analysis: how to secure generation adequacy . . . . .	306
<b>12</b>	<b>Network operations</b>	<b>311</b>
12.1	Introduction . . . . .	311
12.2	Voltage control and reactive power management . . . . .	311
12.2.1	Analysis of voltage control (Step I) . . . . .	312
12.2.2	Voltage control in its context (Step II) . . . . .	314
12.2.3	The organisation of voltage control (Step III) . . . . .	315
12.2.4	Conclusion . . . . .	319
12.3	N - 1 security . . . . .	319
12.3.1	The analysis of N-1 security as a function (Step I) . . . . .	320
12.3.2	The context of N-1 security (Step II) . . . . .	322

12.3.3	Design of the rules for ‘N-1 security’(Step III)	323
12.3.4	Conclusion	325
12.4	Other network operations functions	325
12.4.1	Flow management	326
12.4.2	Network-faults clearing and short-circuit currents	327
12.4.3	Black-start capacity	328
<b>13</b>	<b>Congestion management</b>	<b>329</b>
13.1	Introduction	329
13.2	Criteria for congestion management methods	333
13.3	Calculation of the amount of available capacity	336
13.4	Congestion management methods	337
13.5	Corrective methods: Redispatching and countertrading	338
13.6	Allocation methods	341
13.6.1	General overview	341
13.6.2	Explicit auctioning	342
13.6.3	Implicit auctioning	345
13.6.4	Market splitting and market coupling	347
13.7	Evaluation of congestion management methods	350
13.8	Designing congestion management	354
13.9	Conclusion	360
<b>14</b>	<b>Transport adequacy</b>	<b>365</b>
14.1	Introduction	365
14.2	Analysis of transport adequacy (Step I)	365
14.3	Transport adequacy in its context (Step II)	368
14.4	The organisation of transport adequacy (Step III)	371
14.5	Quality regulation	378
14.5.1	The need for risk governance	378
14.5.2	The quality objective	382
14.5.3	The policy instruments	384
14.5.4	Can the time lag problem be overcome?	387
14.5.5	Conclusion	388
14.6	Conclusion	389
<b>15</b>	<b>Merchant investment in interconnectors?</b>	<b>391</b>
15.1	Interconnection investment	391
15.2	Why merchant interconnectors?	393
15.3	Standard regulation of transmission	395
15.4	Economics of merchant interconnectors	398
15.5	The special regime of the Regulation	401
15.6	The Estlink decisions	407
15.7	Analysis and conclusion: a Trojan horse?	412
<b>16</b>	<b>Validation of the method</b>	<b>417</b>
16.1	Introduction	417

16.2	The theory behind validation of the method . . . . .	418
16.3	Validation of the FULDA-method . . . . .	422
16.4	The FULDA-method as a decision support tool . . . . .	430
16.5	The impact of the context on the method: comparison EU-US . . . . .	438
16.6	Strategy for a thorough validation . . . . .	443
<b>17</b>	<b>Conclusion</b>	<b>449</b>
17.1	The need for restructuring the legal organisation . . . . .	449
17.2	Design criteria . . . . .	451
17.3	Design approach and FULDA-method . . . . .	454
17.4	Our design for reliable electricity supply . . . . .	456
17.5	Assessment: does the design meet the criteria? . . . . .	456
<b>18</b>	<b>Reflection</b>	<b>469</b>
18.1	Introduction . . . . .	469
18.2	Responsibility for the design . . . . .	469
18.3	Responsibility for organising a function . . . . .	471
18.4	The role of technology . . . . .	475
18.5	Comparison with practice . . . . .	478
18.6	The need for coordination . . . . .	483
18.7	Further research . . . . .	484
	<b>Appendix</b>	
	<b>Case study: the maintenance of the energy balance</b>	<b>487</b>
A.1	Introduction . . . . .	487
A.2	European rules for the function . . . . .	487
A.3	Maintenance of the energy balance in the UCTE system . . . . .	489
A.4	Selecting the countries for the case studies . . . . .	493
A.5	The Netherlands . . . . .	494
A.6	Belgium . . . . .	498
A.7	France . . . . .	503
A.8	England and Wales . . . . .	507
A.9	Germany . . . . .	511
	<b>Bibliography</b>	<b>519</b>
	<b>List of EC Legislation</b>	<b>535</b>
	<b>Summary</b>	<b>537</b>
	<b>Samenvatting</b>	<b>549</b>
	<b>Curriculum vitae</b>	<b>565</b>

# LIST OF TABLES

4.1	Classification of HOHFELD’s fundamental legal conceptions . . . . .	70
5.1	Problems with the goal of ‘affordability’ . . . . .	100
5.2	Indicators and objectives for affordability . . . . .	101
7.1	Relevant questions in step I of the FULDA-method . . . . .	173
7.2	Relevant questions in step II of the FULDA-method . . . . .	179
8.1	The functions of NERC’s Reliability Functional Model compared to our technical functions . . . . .	219
8.2	Inventory of technical functions . . . . .	223
10.1	Imposition of responsibility for the maintenance of the energy balance in the countries studied in the Appendix . . . . .	252
10.2	Overview of the results of the case study of the Appendix as to who is responsible for the maintenance of the energy balance . . . . .	256
10.3	Overview of the results of the case study of the Appendix as to whether government had prespecified the organisation of the ‘reserves market’	262
10.4	Prescription of the order of measures for the maintenance of the energy balance in some of the countries studied in the Appendix . . . . .	265
13.1	Overview of the characteristics of congestion management methods . . . . .	355
17.1	Overview of whether some actor should be explicitly responsible for a function, and who that actor should be . . . . .	457
17.2	Overview of the further organisation of and control possibilities for generation-related functions . . . . .	458
17.3	Overview of the further organisation of and control possibilities for network operations functions . . . . .	459
17.4	Overview of the further organisation of and control possibilities for transport adequacy . . . . .	460

## LIST OF FIGURES

1.1	Model 1: competition for electricity generation . . . . .	8
1.2	Model 2: wholesale competition for electricity . . . . .	9
1.3	Model 3: full supply competition for electricity . . . . .	10
1.4	How liberalisation has changed the contractual framework . . . . .	11
	(a) Contractual situation of the Dutch electricity consumer <i>before</i> liberalisation . . . . .	11
	(b) Contractual situation of the Dutch electricity consumer <i>after</i> liberalisation . . . . .	11
1.5	The changing position of government . . . . .	14
	(a) Before liberalisation . . . . .	14
	(b) After liberalisation . . . . .	14
1.6	Systems may be physically coupled, but institutional organisation is still different . . . . .	17
2.1	The ‘meta model’ for the design process . . . . .	31
2.2	Different possible shapes of a flower vase . . . . .	33
2.3	The X-shaped vase . . . . .	34
2.4	The ‘meta model’ applied to this research . . . . .	36
2.5	Structure of this thesis . . . . .	39
3.1	Chapter 3 in the structure of this thesis. . . . .	43
3.2	Structure of the electricity system and organisation of this chapter . . . . .	44
3.3	Structure of the technical subsystem and organisation of this section . . . . .	45
3.4	Schematic picture of the Dutch transmission and distribution networks . . . . .	48
3.5	A schematic picture of the physical layer of the technical subsystem . . . . .	49
3.6	The operational layer of the technical subsystem . . . . .	51
3.7	From network dominance to market dominance . . . . .	53
3.8	The actors in the market . . . . .	55
3.9	The hybrid market model . . . . .	56
3.10	Links from the technical to the economic subsystem . . . . .	58
3.11	Links from the economic to the technical subsystem . . . . .	61
4.1	Chapter 4 in the structure of this thesis . . . . .	65
4.2	Policy <i>instruments</i> as an intermediate concept . . . . .	73

5.1	Chapter 5 within the structure of this thesis . . . . .	92
6.1	The position of chapter 6 in the structure of this thesis . . . . .	111
7.1	The position of chapter 7 in the structure of the thesis . . . . .	164
7.2	Structure of the FULDA-method . . . . .	168
7.3	Structure of step III of the FULDA-method . . . . .	181
10.1	The structure and organisation of the interconnected UCTE network . .	245
13.1	The problem of congestion . . . . .	337
13.2	Redispatching . . . . .	339
13.3	Explicit auctioning . . . . .	343
13.4	Implicit auctioning . . . . .	346
13.5	Market coupling . . . . .	348
13.6	Market splitting . . . . .	349
14.1	Reliability data for several European countries . . . . .	381
14.2	Policy instruments for quality regulation . . . . .	384
17.1	Structure of the FULDA-method . . . . .	455
A.1	The situation in western and central Europe in 2003 as regards the institutional organisation . . . . .	490
	Structure of the FULDA-method . . . . .	541
	Structuur van de FULDA-methode . . . . .	554