

Rafael Cayuela Valencia

# The Future of the Chemical Industry by 2050



*Rafael Cayuela Valencia*

## **The Future of the Chemical Industry by 2050**



**WILEY-  
VCH**

**WILEY-VCH Verlag GmbH & Co. KGaA**

## The Author

**Rafael Cayuela Valencia**

Holzmoosrütistr. 6

8820 Wädenswil

Zurich

Switzerland

All books published by Wiley-VCH are carefully produced. Nevertheless, authors, editors, and publisher do not warrant the information contained in these books, including this book, to be free of errors. Readers are advised to keep in mind that statements, data, illustrations, procedural details or other items may inadvertently be inaccurate.

**Library of Congress Card No.:** applied for

### **British Library Cataloguing-in-Publication Data**

A catalogue record for this book is available from the British Library.

### **Bibliographic information published by the Deutsche Nationalbibliothek**

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <<http://dnb.d-nb.de>>.

© 2013 Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany

All rights reserved (including those of translation into other languages). No part of this book may be reproduced in any form – by photoprinting, microfilm, or any other means – nor transmitted or translated into a machine language without written permission from the publishers. Registered names, trademarks, etc. used in this book, even when not specifically marked as such, are not to be considered unprotected by law.

**Typesetting** Laserwords Private Limited, Chennai, India

**Printing and Binding** Markono Print Media Pte Ltd, Singapore

**Cover Design** Grafik-Design Schulz, Fußgönheim

**Print ISBN:** 978-3-527-33257-1

**ePDF ISBN:** 978-3-527-65702-5

**ePub ISBN:** 978-3-527-65701-8

**mobi ISBN:** 978-3-527-65700-1

**oBook ISBN:** 978-3-527-65699-8

## Contents

**Preface** IX

**Acknowledgments** XIII

**Introduction** 1

Methodology 4

<b>1</b>	<b>Global Megatrends by 2050</b>	<b>11</b>
1.1	Social Megatrends	16
1.1.1	Population Growth	16
1.1.2	Demographics	18
1.1.2.1	Area and Age Distribution	18
1.1.2.2	Change in Age Distribution	18
1.1.3	Urbanization	25
1.1.3.1	Megacities	27
1.2	Economic Megatrends	29
1.2.1	Foreign Direct Investment(FDI)	40
1.3	Political Megatrend	42
1.3.1	Trend – A New International Order	43
1.3.1.1	Sub Trend – the Emergence of the BRIC Economies	43
1.3.1.2	Sub Trend – Corporate Mega Economies – (CME)	46
1.3.1.3	Sub trend – Social Networks	50
1.3.2	Trend – An increasing role of Governments	54
1.4	Energy Megatrends	61
1.4.1	Recent Energy Transitions	63
1.4.2	Key Lessons from Recent Energy Mix Transitions	69
1.4.3	Energy Life Cycle	69
1.4.4	Energy Success Criteria	69
1.4.5	Shocks Are a Valuable Source of Information	70
1.4.6	Transitions Occur in “Life”	70
1.4.7	The Golden Rule – Economics Dictate Energy Transitions	70
1.4.8	Transitions Always Occur, the Question Is When: The Oil Peak	71
1.4.9	The Oil Peak – M.King Hubbert	74

1.4.10	OPEC – Energy projections to 2030	75
1.4.11	Recent Developments	80
1.4.11.1	Nuclear Energy – The Aftermath of Fukushima	80
1.4.11.2	Shale Gas the “Game Changer” – Natural Gas the Energy of the Future	85
1.5	Climate Change	99
1.5.1	Business Case – EU Tire Labeling – CO <sub>2</sub> Emissions Reduction in the Tire and Automotive Industry	113
1.6	Wild Cards	129
1.6.1	Political	131
1.6.2	Social	131
1.6.3	Technological	132
1.6.4	Transportation	132
1.7	Accelerators – Information Technology and “Singularity”	132
	Appendix: Climate Change	139
<b>2</b>	<b>The World by 2050</b>	<b>141</b>
2.1	“A Much Larger, Wealthier, Healthier, and Sustainable World”	141
2.1.1	Methodology	144
2.2	Status of the World – 2010	145
2.3	The World in 2050	146
2.3.1	BAU Scenario	146
2.3.2	Sustainable Scenario	155
	Appendix: Roadmaps to a World of 4000 g of CO <sub>2</sub> per Capita per Day	161
<b>3</b>	<b>The Chemical Industry in 2010</b>	<b>163</b>
3.1	Chemical Industry: Economic Relevance	163
3.2	Chemical Industry: Technological Relevance	166
3.3	Industry Relevance: Profitability	168
3.4	Feedstocks and Energy	171
3.5	Major Sectors and Products of the Chemical Industry	173
3.6	Industry Structure and Companies	173
3.7	Safety	184
3.8	Background	186
3.8.1	Recent History of the Chemical Industry Excluding Pharmaceuticals	186
3.8.1.1	1750–1850 Industrial Revolution and Inorganic Chemistry	187
3.8.1.2	1850 Synthetic Dyes from Coal for Textiles, and Chlorine Bleach	187
3.8.1.3	1870 Celluloid	187
3.8.1.4	1880 Rayon from Wood Fibers	188
3.8.1.5	1900 Electrolysis of Brine (Chlorine)	188
3.8.1.6	1913 Synthetic Fertilizers	189
3.8.1.7	1910–1920 Steam Cracker (Ethylene, Propylene and Butadiene)	190

3.8.1.8	1920–1930 – Styrene Cracking (Ethyl-benzene and Styrene) Cracking	190
3.8.1.9	Polyamide Nylon (DuPont)	190
3.8.1.10	1930s – Synthetic Rubber	190
3.8.1.11	1950s – Plastics Demand Explodes	191
3.8.1.12	1960s Internationalization	194
3.8.1.13	2010–2050 – The Chemical Industry Leads the Revolution against Climate Change	194
3.9	Conclusion	194
3.10	Summary – Industry Major Features and Upcoming Megatrends	195
3.11	Major Features of the Chemical Industry	197
3.11.1	Summary: Global Major Megatrends	199
	Bibliography	200
<b>4</b>	<b>Impact Assessment of the Global Megatrends on the Chemical Industry</b>	<b>201</b>
4.1	Introduction	201
4.2	Megatrends with the Highest Impact into the Chemical Industry (Global & Area Level)	207
4.3	Megatrends with the Highest Impact in the Industry (Area Level) – (Figure 4.4)	208
4.4	Megatrends with the Highest Impact into the Different Features of the Industry	210
4.5	Major Results for the Chemical Industry Globally	212
4.6	Major Results for the Chemical Industry in the ADV Economies	214
4.7	Major Results for the Chemical Industry in the BRIC Economies	216
4.8	Major Results for the Chemical Industry in the REST Economies	218
<b>5</b>	<b>The Chemical Industry by 2050</b>	<b>221</b>
5.1	Introduction	221
5.2	Feature 1: The Relevance of the Chemical Industry	225
5.2.1	Economic Relevance	226
5.2.1.1	Chemicals and Pharmaceuticals by 2050 – per Capita Demand in \$US	229
5.2.2	Technological Relevance	236
5.2.2.1	The Chemical Industry – Long Term Cycles	236
5.2.3	Profitability	241
5.3	Feature 2: Inputs – Feedstocks	245
5.3.1	BAU Scenario for Feedstocks by 2050	247
5.3.2	Feedstock Simulation II by 2050: “Shale Gas I – Ethane + 20% Globally”	250
5.3.3	Simulation II by 2050: “Shale Gas II – Ethane at Maximum Capacity Globally” – (Unreal)	252
5.3.4	Conclusion and Feedstock Alternatives	254

5.4	Feature 3: Outputs – Products	256
5.4.1	Global Ethylene Market by 2050 – BAU Scenario	258
5.5	Feature 4: Climate Change – Greenhouse Emissions – CO <sub>2</sub> Emissions	264
5.5.1	Historical and Future Scenarios on World CO <sub>2</sub> Emissions	268
5.5.2	Summary – Global Emission Trading Systems in Operation	277
5.5.2.1	Chemical Industry – Greenhouse Emissions Abatement in 2005	281
5.6	Feature 5: Industry Structure	283
5.6.1	Markets – Largest World Markets	284
5.6.1.1	Chemicals	284
5.6.1.2	Pharmaceuticals	284
5.6.2	Per Capita Demand	287
5.6.2.1	Chemicals	287
5.6.2.2	Pharmaceuticals	289
5.6.3	Companies – Changes in Global Sales Rankings and Company Structures	291
5.7	Feature 6: Social Awareness	294
	Appendix – Climate Change	296
<b>6</b>	<b>Conclusion</b>	<b>307</b>
	Appendix	315
	<b>Index</b>	<b>319</b>