

**TECHNOLOGY & COSTS****Technoeconomics - Energy & Chemicals (TECH)****TECH 2021-5 Chlor-Alkali**

## Table of Contents

A Report by **NexantECA, the Energy and Chemical Advisory company**

Published Date: June 2021

[www.nexanteca.com/subscriptions-and-reports](http://www.nexanteca.com/subscriptions-and-reports)**Contents**

|       |  |    |
|-------|--|----|
| 1     | Executive Summary .....  | 1  |
| 1.1   | Introduction.....  | 1  |
| 1.2   | Overview of Technology .....                                   | 2  |
| 1.3   | Technology Licensors .....                                     | 3  |
| 1.3.1 | Asahi Kasei Chemicals Corporation.....                         | 3  |
| 1.3.2 | thyssenkrupp Uhde Chlorine Engineers.....                      | 3  |
| 1.3.3 | INOVYN.....  | 3  |
| 1.3.4 | BlueStar Chemical Machinery Company Limited.....               | 3  |
| 1.3.5 | Summary .....  | 3  |
| 1.4   | Environmental Regulations .....                                | 4  |
| 1.4.1 | Mercury and Mercury Cell Process .....                         | 5  |
| 1.5   | Process Economics.....   | 5  |
| 1.6   | Global Chlorine Supply and Demand .....                        | 9  |
| 1.6.1 | Global Chlorine Demand .....                                   | 9  |
| 1.6.2 | Global Chlorine Supply.....                                    | 10 |
| 1.6.3 | Global Chlorine Supply/Demand Balance .....                    | 11 |
| 1.6.4 | North America Chlorine Supply/Demand Balance .....             | 11 |
| 1.6.5 | Western Europe Chlorine Supply/Demand Balance .....            | 11 |
| 1.6.6 | Asia Pacific Chlorine Supply/Demand Balance .....              | 12 |
| 1.6.7 | Rest of the World Chlorine Supply/Demand Balance .....         | 12 |
| 1.7   | Global Sodium Hydroxide Supply and Demand .....                | 13 |
| 1.7.1 | Global Sodium Hydroxide Demand.....                            | 13 |
| 1.7.2 | Global Sodium Hydroxide Supply .....                           | 14 |
| 1.7.3 | Global Sodium Hydroxide Supply/Demand Balance .....            | 14 |
| 1.7.4 | North America Sodium Hydroxide Supply/Demand Balance .....     | 14 |
| 1.7.5 | Western Europe Sodium Hydroxide Supply/Demand Balance .....    | 14 |
| 1.7.6 | Asia Pacific Sodium Hydroxide Supply/Demand Balance .....      | 15 |
| 1.7.7 | Rest of the World Sodium Hydroxide Supply/Demand Balance ..... | 15 |
| 2     | Introduction.....  | 16 |

|        |  |    |
|--------|--|----|
| 2.1    | Overview.....  | 16 |
| 2.2    | Conventional Technology.....                             | 17 |
| 2.3    | Technology Licensors .....                               | 18 |
| 2.3.1  | Asahi Kasei Chemicals Corporation.....                   | 18 |
| 2.3.2  | thyssenkrupp Uhde Chlorine Engineers.....                | 18 |
| 2.3.3  | INOVYN.....  | 18 |
| 2.3.4  | BlueStar Chemical Machinery Company Limited.....         | 18 |
| 2.3.5  | Summary .....  | 18 |
| 2.4    | Major Producers .....                                    | 19 |
| 2.5    | Characteristics and Properties .....                     | 20 |
| 2.6    | Environmental Regulations .....                          | 21 |
| 2.6.1  | Mercury and Mercury Cell Process .....                   | 21 |
| 3      | Background .....   | 22 |
| 3.1    | Electrochemical Basic Theory Outlined .....              | 22 |
| 3.1.1  | Thermodynamics.....                                      | 24 |
| 3.1.2  | Kinetics .....   | 25 |
| 3.1.3  | Bubbles .....  | 26 |
| 3.1.4  | Summary .....  | 26 |
| 3.2    | Parasitic Loss Reactions .....                           | 27 |
| 3.3    | Brine Supply .....                                       | 27 |
| 3.3.1  | Calcium, Magnesium, and Trace Metals.....                | 28 |
| 3.3.2  | Sulfates .....   | 29 |
| 3.3.3  | Fluorides, Iodides, and Organics .....                   | 29 |
| 3.3.4  | Chlorine .....   | 29 |
| 3.3.5  | Brine Treatment Unit .....                               | 30 |
| 3.3.6  | Waste Brine .....  | 33 |
| 3.4    | Electricity Supply .....                                 | 33 |
| 3.5    | Electrical Energy Consumptions and Heating.....          | 34 |
| 3.6    | Piping.....  | 35 |
| 3.7    | Water .....  | 35 |
| 3.8    | Electrode Configuration (Bipolar versus Monopolar) ..... | 36 |
| 3.9    | Leakage Current.....                                     | 37 |
| 3.10   | Electrodes (Material of Construction) .....              | 38 |
| 3.10.1 | Anodes .....   | 38 |
| 3.10.2 | Cathodes .....   | 39 |
| 4      | Chlor-Alkali Technologies.....                           | 40 |
| 4.1    | Introduction.....  | 40 |
| 4.2    | Mercury Cells .....                                      | 41 |
| 4.3    | Diaphragm Cells .....                                    | 46 |
| 4.4    | Membrane Cells .....                                     | 50 |
| 4.4.1  | Ion Exchange Membrane .....                              | 53 |
| 4.4.2  | Asahi Kasei Chemicals Corporation.....                   | 54 |

|       |   |    |
|-------|---|----|
| 4.4.3 | thyssenkrupp Uhde Chlorine Engineers.....                   | 55 |
| 4.4.4 | INOVYN.....   | 57 |
| 4.4.5 | BlueStar (Beijing) Chemical Machinery Company Limited ..... | 58 |
| 4.5   | Fuel Cell Integrated Systems .....                          | 59 |
| 4.6   | Oxygen Depolarized Cathodes .....                           | 62 |
| 4.7   | Hydrogen Processing .....                                   | 65 |
| 4.8   | Chlorine Processing .....                                   | 66 |
| 4.8.1 | Cooling .....   | 66 |
| 4.8.2 | Drying .....  | 67 |
| 4.8.3 | Compression .....   | 67 |
| 4.8.4 | Liquefaction .....  | 68 |
| 4.8.5 | Materials of Construction .....                             | 68 |
| 4.8.6 | Storage and Shipping.....                                   | 68 |
| 4.9   | Sodium Hydroxide Processing .....                           | 69 |
| 4.9.1 | Mercury Cell .....  | 70 |
| 4.9.2 | Diaphragm Cell.....   | 70 |
| 4.9.3 | Membrane Cell.....  | 70 |
| 4.9.4 | Concentrated and Solid Sodium Hydroxide .....               | 70 |
| 4.9.5 | Materials of Construction .....                             | 71 |
| 4.9.6 | Storage and Shipping.....                                   | 71 |
| 4.10  | Effluent Processing .....                                   | 71 |
| 5     | Developing Technologies and Alternate Routes .....          | 75 |
| 5.1   | Introduction.....   | 75 |
| 5.2   | Electrochemical .....                                       | 75 |
| 5.2.1 | Electrolysis of KCl .....                                   | 75 |
| 5.2.2 | Electrolysis of Molten Salts .....                          | 75 |
| 5.2.3 | Electrolysis of HCl .....                                   | 76 |
| 5.3   | Membraneless Technology .....                               | 79 |
| 5.3.1 | Background .....  | 79 |
| 5.3.2 | Swiss Federal Institute of Technology Lausanne (EPFL) ..... | 79 |
| 5.3.3 | Columbia University of New York.....                        | 80 |
| 5.3.4 | Fudan University .....                                      | 81 |
| 5.4   | Chemical Catalytic Oxidation .....                          | 82 |
| 5.4.1 | Background .....  | 82 |
| 5.4.2 | Deacon Process .....  | 82 |
| 5.4.3 | MT-Chlor Process .....                                      | 82 |
| 5.4.4 | Kel-Chlor Process .....                                     | 82 |
| 5.4.5 | Sumitomo HCl Oxidation Process.....                         | 83 |
| 5.5   | Recent Patent Developments .....                            | 85 |
| 5.5.1 | Axiall (PPG Industries) .....                               | 86 |
| 5.5.2 | DOW.....  | 86 |
| 5.5.3 | thyssenkrupp Uhde Chlorine Engineers.....                   | 87 |

|       |   |     |
|-------|---|-----|
| 5.5.4 | De Nora .....   | 88  |
| 5.5.5 | Uhdenora.....   | 89  |
| 6     | Process Economics .....   | 91  |
| 6.1   | Costing Basis .....   | 91  |
| 6.1.1 | Investment Basis.....   | 91  |
| 6.1.2 | Pricing Basis.....  | 91  |
| 6.1.3 | Cost of Production Basis .....  | 93  |
| 6.2   | Chlor-alkali via Mercury Cell .....   | 94  |
| 6.3   | Chlor-alkali via Diaphragm Cell .....   | 96  |
| 6.4   | Chlor-alkali via Membrane Cell Technology.....  | 98  |
| 6.5   | Chlor-alkali via Membrane Cell with Oxygen Diffusion Cathode.....                           | 103 |
| 6.6   | Chlor-alkali via Membrane Cell with Integrated Fuel Cell .....                              | 106 |
| 6.7   | Chlorine via Sumitomo HCl Oxidation.....  | 109 |
| 6.8   | Comparison of Technologies .....  | 112 |
| 6.9   | Economic Sensitivity Analyses.....  | 115 |
| 6.9.1 | Sensitivity of Sodium Chloride Feedstock Price on Production Cost.....                      | 115 |
| 6.9.2 | Sensitivity of Electricity Price on Production Cost.....                                    | 116 |
| 6.9.3 | Sensitivity of Plant Capacity on Cost of Production plus 10 percent<br>ROCE .....           | 117 |
| 6.9.4 | Sensitivity of Hydrogen Value on Costs of Production.....                                   | 118 |
| 6.9.5 | Sensitivity of Total Project Investment on Cost of Production plus 10<br>percent ROCE ..... | 119 |
| 6.9.6 | Membrane Technology Time Series .....   | 120 |
| 7     | Commercial Applications .....   | 122 |
| 7.1   | Chlorine .....  | 122 |
| 7.2   | Sodium Hydroxide (Caustic Soda) .....   | 123 |
| 8     | Regional Market Analysis.....   | 124 |
| 8.1   | Global .....  | 124 |
| 8.1.1 | Chlorine Demand .....   | 124 |
| 8.1.2 | Chlorine Supply .....   | 125 |
| 8.1.3 | Chlorine Supply/Demand Balance .....  | 126 |
| 8.1.4 | Sodium Hydroxide Demand .....   | 127 |
| 8.1.5 | Sodium Hydroxide Supply .....   | 128 |
| 8.1.6 | Sodium Hydroxide Supply/Demand Balance .....  | 128 |
| 8.2   | North America .....   | 129 |
| 8.2.1 | Chlorine Demand .....   | 129 |
| 8.2.2 | Chlorine Supply .....   | 130 |
| 8.2.3 | Chlorine Supply/Demand Balance .....  | 131 |
| 8.2.4 | Sodium Hydroxide Demand .....   | 132 |
| 8.2.5 | Sodium Hydroxide Supply .....   | 133 |
| 8.2.6 | Sodium Hydroxide Supply/Demand Balance .....  | 133 |
| 8.3   | Western Europe .....  | 134 |

|       |  |     |
|-------|--|-----|
| 8.3.1 | Chlorine Demand .....                        | 134 |
| 8.3.2 | Chlorine Supply .....                        | 134 |
| 8.3.3 | Chlorine Supply/Demand Balance .....         | 137 |
| 8.3.4 | Sodium Hydroxide Demand .....                | 138 |
| 8.3.5 | Sodium Hydroxide Supply .....                | 138 |
| 8.3.6 | Sodium Hydroxide Supply/Demand Balance ..... | 138 |
| 8.4   | Asia Pacific .....                           | 139 |
| 8.4.1 | Chlorine Demand .....                        | 139 |
| 8.4.2 | Chlorine Supply .....                        | 140 |
| 8.4.3 | Chlorine Supply/Demand Balance .....         | 146 |
| 8.4.4 | Sodium Hydroxide Demand .....                | 147 |
| 8.4.5 | Sodium Hydroxide Supply .....                | 147 |
| 8.4.6 | Sodium Hydroxide Supply/Demand Balance ..... | 147 |
| 8.5   | ROW .....                                    | 148 |
| 8.5.1 | Chlorine Supply .....                        | 148 |
| 8.5.2 | Chlorine Supply/Demand Balance .....         | 150 |
| 8.5.3 | Sodium Hydroxide Supply .....                | 151 |
| 8.5.4 | Sodium Hydroxide Supply/Demand Balance ..... | 151 |
| 9     | Glossary .....                               | 152 |

## Appendices

|   |   |     |
|---|---|-----|
| A | Definitions of Capital Cost Terms Used in Process Economics .....   | 155 |
| B | Definitions of Operating Cost Terms Used in Process Economics ..... | 160 |
| C | TECH Program Title Index (2011-2021) .....                          | 163 |
| D | References .....  | 166 |

## Figures

|           |  |     |
|-----------|--|-----|
| Figure 1  | The Chlor-Alkali Value Chain .....   | 1   |
| Figure 2  | Comparison of Costs of Production for Conventional Technologies .....  | 6   |
| Figure 3  | Comparison of Cost of Electrical Energy Conventional Technologies .....  | 6   |
| Figure 4  | Regional Comparison of Chlor-Alkali Costs for Bipolar Membrane Cell Technology .....   | 7   |
| Figure 5  | Comparison of Electricity Conserving Technologies .....  | 8   |
| Figure 6  | Global Chlorine Demand by Application, 2020.....   | 10  |
| Figure 7  | Global Chlorine Capacity by Region, 2020 .....   | 10  |
| Figure 8  | Global Sodium Hydroxide Demand by Application, 2020 .....  | 13  |
| Figure 9  | The Chlor-Alkali Value Chain .....   | 16  |
| Figure 10 | Electrode Potential – pH Relationship of Part of the Chlorine – Water System .....   | 24  |
| Figure 11 | Chlorine Activity-pH Diagram .....   | 30  |
| Figure 12 | Brine Preparation Process Block Diagram .....  | 30  |
| Figure 13 | Simplified Representation of Monopolar and Bipolar Electrolyzer Configuration.....   | 36  |
| Figure 14 | Manifolding Option to Increase Path Length .....   | 38  |
| Figure 15 | Global Mercury Cell Chlor-Alkali Plants Capacity .....   | 41  |
| Figure 16 | Mercury Cell Process Block Flow Diagram .....  | 42  |
| Figure 17 | Schematic of a Mercury Cell.....   | 44  |
| Figure 18 | Schematic of Hg-Na Amalgam Decomposer with De Nora Improvement.....  | 45  |
| Figure 19 | Diaphragm Cell Process .....   | 47  |
| Figure 20 | Schematic Representation of a Diaphragm Cell .....   | 48  |
| Figure 21 | Membrane Cell Process Block Flow Diagram .....   | 51  |
| Figure 22 | Schematic of a Membrane Cell .....   | 52  |
| Figure 23 | Proton Exchange Membrane Fuel Cell .....   | 60  |
| Figure 24 | Schematic Representation of Membrane Cell with an Oxygen Diffusion Electrode .....   | 62  |
| Figure 25 | pH-Potential Diagram of Part of the Chlorine–Water System with Reduction of Oxygen and Hydrogen on Suitable Catalytic Surfaces Platinum and Nickel ..... | 63  |
| Figure 26 | Chlorine Handling Block Flow Diagram .....   | 66  |
| Figure 27 | Treatment of the Sodium Hydroxide Solution from Various Electrolysis Cells .....   | 69  |
| Figure 28 | Schematic Diagram for the Extraction of Mercury from Brine Sludge .....  | 73  |
| Figure 29 | Aqueous HCl Electrolysis Comparison.....   | 77  |
| Figure 30 | DuPont Anhydrous HCl Process .....   | 78  |
| Figure 31 | Design of Membraneless Cell by EPFL.....   | 79  |
| Figure 32 | Design of Membraneless Cell by Columbia University of New York .....   | 80  |
| Figure 33 | Illustration of Sodium Ion De-intercalation/Intercalation Mechanism .....  | 81  |
| Figure 34 | Sumitomo Chemical Process .....  | 84  |
| Figure 35 | Comparison of Costs of Production for Conventional Technologies .....  | 112 |
| Figure 36 | Comparison of Cost of Electrical Energy Conventional Technologies .....  | 113 |
| Figure 37 | Regional Comparison of Chlor-Alkali Costs for Bipolar Membrane Cell Technology .....   | 113 |
| Figure 38 | Comparison of Electricity Conserving Technologies .....  | 114 |
| Figure 39 | Sensitivity of Cost of Production to Price of Sodium Chloride.....   | 115 |
| Figure 40 | Cost of Production Sensitivity to Variation in Power Pricing .....   | 116 |

|           |   |     |
|-----------|---|-----|
| Figure 41 | Variation in Cost of Production with Plant Scale .....                        | 117 |
| Figure 42 | Variation in Cost of Production with Value of Hydrogen in Western Europe..... | 118 |
| Figure 43 | Variation in Cost of Production with Value of Hydrogen in China .....         | 118 |
| Figure 44 | Sensitivity to Total Project Investment, Percentage of Base Case .....        | 119 |
| Figure 45 | Cost of Production of Membrane Technology Time Series, Western Europe .....   | 120 |
| Figure 46 | Cost of Production of Membrane Technology Time Series, China .....            | 121 |
| Figure 47 | Global Chlorine Demand by Application, 2020.....                              | 124 |
| Figure 48 | Global Chlorine Capacity by Region, 2020 .....                                | 126 |
| Figure 49 | Global Chlorine Supply and Demand .....                                       | 127 |
| Figure 50 | Global Sodium Hydroxide Demand by Application, 2020 .....                     | 128 |
| Figure 51 | Global Sodium Hydroxide Supply and Demand .....                               | 129 |
| Figure 52 | North America Chlorine Supply and Demand .....                                | 132 |
| Figure 53 | North America Sodium Hydroxide Supply/Demand Balance .....                    | 133 |
| Figure 54 | Western Europe Chlorine Supply and Demand .....                               | 137 |
| Figure 55 | Western Europe Sodium Hydroxide Supply/Demand Balance .....                   | 138 |
| Figure 56 | Asia Pacific Chlorine Supply/Demand Balance .....                             | 146 |
| Figure 57 | Sodium Hydroxide Supply/Demand Balance .....                                  | 147 |
| Figure 58 | ROW Chlorine Supply/Demand Balance .....                                      | 150 |
| Figure 59 | ROW Sodium Hydroxide Supply/Demand Balance.....                               | 151 |

## Tables

|          |  |     |
|----------|--|-----|
| Table 1  | Summary Strengths and Weaknesses – Mercury versus Diaphragm versus Membrane.....   | 2   |
| Table 2  | Key Technology Licensor Summary.....   | 4   |
| Table 3  | Regional Demand for Chlorine .....   | 9   |
| Table 4  | Global Chlorine Supply and Demand .....  | 11  |
| Table 5  | North America Chlorine Supply and Demand .....   | 11  |
| Table 6  | Western Europe Chlorine Supply and Demand .....  | 11  |
| Table 7  | Asia Pacific Chlorine Supply/Demand Balance.....   | 12  |
| Table 8  | ROW Chlorine Supply/Demand Balance.....  | 12  |
| Table 9  | Regional Demand for Sodium Hydroxide .....   | 13  |
| Table 10 | Global Sodium Hydroxide Supply and Demand .....  | 14  |
| Table 11 | North America Sodium Hydroxide Supply/Demand Balance .....   | 14  |
| Table 12 | Western Europe Sodium Hydroxide Supply/Demand Balance .....  | 14  |
| Table 13 | Asia Pacific Sodium Hydroxide Supply/Demand Balance.....   | 15  |
| Table 14 | ROW Sodium Hydroxide Supply/Demand Balance.....  | 15  |
| Table 15 | Summary Strengths and Weaknesses – Mercury versus Diaphragm versus Membrane.....   | 17  |
| Table 16 | Key Technology Licensor Summary.....   | 19  |
| Table 17 | Key Physical and Thermodynamic Properties of Chlorine .....  | 20  |
| Table 18 | Key Physical and Thermodynamic Properties of Sodium Hydroxide .....  | 20  |
| Table 19 | Typical Specifications for Feed Brine to Electrolyzers .....   | 31  |
| Table 20 | Salt Loss in Waste Brines Purge .....  | 33  |
| Table 21 | Demineralized Water Specifications.....  | 35  |
| Table 22 | Monopolar versus Bipolar Cell Configurations .....   | 37  |
| Table 23 | Product Quality for Typical Membrane Cell Technology .....   | 54  |
| Table 24 | General Operating Characteristics for a Selection of Fuel Cell Technologies .....  | 61  |
| Table 25 | Product Quality and Service Life for Typical Membrane Cell Technology with Oxygen Depolarized Cathode .....                | 65  |
| Table 26 | Pricing Used in Cost of Production Tables .....  | 92  |
| Table 27 | Cost of Production Estimate for Chlor-Alkali Process: Mercury Cell; Western Europe Basis .....                             | 95  |
| Table 28 | Cost of Production Estimate for Chlor-Alkali Process: Diaphragm Cell; Western Europe Basis.....                            | 97  |
| Table 29 | Cost of Production Estimate for Chlor-Alkali Process: Monopolar Membrane Cell; Western Europe Basis .....                  | 99  |
| Table 30 | Cost of Production Estimate for Chlor-Alkali Process: Bipolar Membrane Cell; Western Europe Basis .....                    | 100 |
| Table 31 | Cost of Production Estimate for Chlor-Alkali Process: Bipolar Membrane Cell; China Basis.....                              | 101 |
| Table 32 | Cost of Production Estimate for Chlor-Alkali Process: Bipolar Membrane Cell; USGC Basis.....                               | 102 |
| Table 33 | Cost of Production Estimate for Chlor-Alkali Process: Membrane Cell with Gas Diffusion Cathode; Western Europe Basis ..... | 104 |

|          |  |     |
|----------|--|-----|
| Table 34 | Cost of Production Estimate for Chlor-Alkali<br>Process: Membrane Cell with Gas Diffusion Cathode; China Basis .....         | 105 |
| Table 35 | Cost of Production Estimate for Chlor-Alkali<br>Process: Membrane Cell with Integrated Fuel Cell; Western Europe Basis ..... | 107 |
| Table 36 | Cost of Production Estimate for Chlor-Alkali<br>Process: Membrane Cell with Integrated Fuel Cell; China Basis .....          | 108 |
| Table 37 | Cost of Production Estimate for Chlorine<br>Process: Sumitomo HCl Oxidation; Western Europe Basis .....                      | 110 |
| Table 38 | Cost of Production Estimate for Chlorine<br>Process: Sumitomo HCl Oxidation; China Basis.....                                | 111 |
| Table 39 | Cost of Production of Membrane Technology Time Series, Western Europe .....  | 120 |
| Table 40 | Cost of Production of Membrane Technology Time Series, China .....   | 121 |
| Table 41 | Regional Demand for Chlorine .....   | 124 |
| Table 42 | Global Chlorine Supply and Demand .....  | 126 |
| Table 43 | Regional Demand for Sodium Hydroxide .....   | 127 |
| Table 44 | Global Sodium Hydroxide Supply and Demand .....  | 128 |
| Table 45 | North America Chlor-Alkali Capacity, 2020 .....  | 130 |
| Table 46 | North America Chlorine Supply and Demand .....   | 132 |
| Table 47 | North America Sodium Hydroxide Supply/Demand Balance .....   | 133 |
| Table 48 | Western Europe Chlor-Alkali Capacity, 2020 .....   | 135 |
| Table 49 | Western Europe Chlorine Supply and Demand .....  | 137 |
| Table 50 | Western Europe Sodium Hydroxide Supply/Demand Balance .....  | 138 |
| Table 51 | Asia Pacific Chlorine Capacity, 2020 .....   | 140 |
| Table 52 | Asia Pacific Chlorine Supply/Demand Balance .....  | 146 |
| Table 53 | Sodium Hydroxide Supply/Demand Balance .....   | 147 |
| Table 54 | ROW Chlorine Capacity, 2020 .....  | 148 |
| Table 55 | ROW Chlorine Supply/Demand Balance.....  | 150 |
| Table 56 | ROW Sodium Hydroxide Supply/Demand Balance.....  | 151 |



## TECHNOLOGY & COSTS

# Technoeconomics - Energy & Chemicals (TECH)

The NexantECA Subscriptions' Technoeconomics - Energy & Chemicals (TECH) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. Technoeconomics - Energy & Chemicals (TECH) reports are available as a subscription program or on a single report basis.

### Contact Details:

#### Americas:

Marcos Nogueira Cesar, Vice President, Global Subscriptions and Reports  
Phone: + 1-914-609-0324, e-mail: [mcesar@NexantECA.com](mailto:mcesar@NexantECA.com)

Erica Hill, Client Services Coordinator, Subscriptions and Reports  
Phone: + 1-914-609-0386, e-mail: [ehill@NexantECA.com](mailto:ehill@NexantECA.com)

#### EMEA:

Anna Ibbotson, Vice President, Sales and Marketing  
Phone: +44-207-950-1528, [aibbotson@NexantECA.com](mailto:aibbotson@NexantECA.com)

#### Asia:

Chommanad Thammanayakatip, Managing Consultant  
Phone: +66-2793-4606, email: [chommanadt@NexantECA.com](mailto:chommanadt@NexantECA.com)

NexantECA Subscriptions and Reports provide clients with comprehensive analytics, forecasts and insights for the chemicals, polymers, energy and cleantech industries. Using a combination of business and technical expertise, with deep and broad understanding of markets, technologies and economics, NexantECA provides solutions that our clients have relied upon for over 50 years.

Copyright © 2000-2021 NexantECA (BVI) Limited. All rights reserved