

# THE GLOBAL INDUSTRIAL GAS BUSINESS



CHM041E  
January 2016

Andrew McWilliams  
*Project Analyst*

ISBN: 1-62296-187-0



**BCC Research**  
49 Walnut Park, Building 2  
Wellesley, MA 02481 USA  
866-285-7215 (toll-free within the USA),  
or (+1) 781-489-7301  
[www.bccresearch.com](http://www.bccresearch.com)  
[information@bccresearch.com](mailto:information@bccresearch.com)

## TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
STUDY GOALS AND OBJECTIVES	2
REASONS FOR DOING THE STUDY	2
CONTRIBUTION OF THE STUDY AND INTENDED AUDIENCE	3
SCOPE AND FORMAT	4
METHODOLOGY AND INFORMATION SOURCES	4
ANALYST CREDENTIALS	5
RELATED BCC RESEARCH REPORTS	5
BCC RESEARCH WEBSITE	5
DISCLAIMER	6
CHAPTER 2 SUMMARY	8
<i>SUMMARY TABLE GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, THROUGH 2020 (\$ BILLIONS)</i>	8
<i>SUMMARY FIGURE GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, 2014-2020 (\$ BILLIONS)</i>	8
CHAPTER 3 INDUSTRY OVERVIEW	11
IMPORTANCE OF INDUSTRIAL GASES	11
PRINCIPAL INDUSTRIAL GAS TYPES AND THEIR APPLICATIONS	11
CARBON DIOXIDE	11
HYDROGEN	12
HELIUM	12
NITROGEN	13
OXYGEN	13
CHAPTER 4 TECHNOLOGY ASSESSMENT	15
INDUSTRIAL GAS PRODUCTION TECHNOLOGIES	15
REFORMING	15
Adiabatic Prereforming	16
Tubular (Primary) Reforming	16
Advanced Reforming	16
Sulfur-Passivated Reforming	16
Autothermal Reforming	17
Two-Step Reforming or Combined Tubular and Secondary Reforming	17
Heat-Exchange Reforming	17
Carbon Dioxide Reforming of Methane	18
NONCATALYTIC PARTIAL OXIDATION	18
SHIFT-CONVERSION AND METHANATION TECHNOLOGY	19
Shift Conversion	19
Methanation	19
AIR SEPARATION	19
Oxygen Plant	20
Air Cooling and Purification	20
Cryogenic Distillation	21
Nitrogen Compression	21

<b>TOPIC</b>	<b>PAGE NO.</b>
Major Plant Equipment	21
Rare Gases Separation	22
<i>TABLE 1 PRESSURE AND TEMPERATURE DATA FOR VARIOUS CRYOGENIC INDUSTRIAL GASES</i>	22
Hydrogen and Helium Liquefaction Technology	23
Hydrogen	23
Helium	23
Noncryogenic	23
Adsorption	24
Membranes	24
<b>NEW PRODUCTION TECHNOLOGIES</b>	24
Modification of Existing Technologies	24
Hydrogen-Production Technologies	24
Thermochemical-Production Technologies	24
Natural Gas Steam Reforming	24
Partial Oxidation and Ceramic Membrane Reactor	25
Plasma Reforming	25
Biomass Gasification and Pyrolysis	25
Electrolytic Production Technologies	26
Water Electrolysis	26
Reversible Fuel Cells and Electrolyzers	26
Photolytic Production Technologies	26
Photobiological	26
Photoelectrolysis	27
Emerging Technologies	27
Ceramic Membrane Technology	27
Solar Thermal Production of Syngas	28
<b>DISTRIBUTION TECHNOLOGIES</b>	28
OXYGEN-PRODUCING VACUUM PRESSURE SWING SYSTEMS	29
NITROGEN MEMBRANE SYSTEMS	29
ON-SITE INDUSTRIAL GAS PRODUCTION TECHNOLOGY	29
<i>TABLE 2 TECHNICAL-GRADE INDUSTRIAL GAS PRODUCTION TECHNOLOGIES</i>	30
<i>TABLE 3 AIR-SEPARATION TECHNOLOGY COMPARISON: CRYOGENIC VERSUS NONCRYOGENIC PROCESSES</i>	30
Cryogenic Processes	30
Oxygen Plants	30
Nitrogen Generators: A Low First-Cost Alternative	31
Oxygen Generators Reduce Costs	31
Noncryogenic Processes	31
PSA System: Only Air is Needed	31
Vacuum Pressure-Swing Adsorption System: Reduced Oxygen Costs	31
Membranes: Nitrogen by Pushing a Button	31
Hydrogen, Syngas and Carbon Dioxide	31
Electrolyzers	31
Steam Reforming	32
Carbon Dioxide	32
<b>BULK LIQUID DELIVERY AND STORAGE</b>	32

<b>TOPIC</b>	<b>PAGE NO.</b>
MICROBULK GAS-DELIVERY SYSTEM	33
HIGH-PRESSURE GAS DELIVERY AND STORAGE TECHNOLOGY	33
NITROGEN PUMPING UNITS	33
PIPELINES	33
INDUSTRIAL GAS STORAGE TECHNOLOGY	33
LIQUEFACTION TECHNOLOGY	34
COMPRESSION TECHNOLOGY	34
ABOVE-GROUND STORAGE TECHNOLOGY	34
UNDERGROUND STORAGE TECHNOLOGY	35
TRANSPORTATION AND STORAGE TECHNOLOGIES	35
Compressed Gas Storage Tanks	35
Liquid Storage Tanks	36
Hydrides (High- and Low-Temperature)	36
Zeolites	37
Other Nanostructured Materials	38
END-USER TECHNOLOGIES	39
PETROLEUM PRODUCTION AND REFINING TECHNOLOGY	39
Enhanced Oil Recovery Technology	39
Enhanced Oil Recovery with Carbon Dioxide	39
Storage Capacity of Oil Reservoirs	40
Carbon Dioxide-Enhanced Oil-Recovery Limitations	40
Nitrogen-Enhanced Oil Recovery	40
Petroleum-Refining Technology	40
Hydroprocessing Technologies	41
<i>TABLE 4 HYDROTREATING REACTIONS OF DIFFERENT REFINERY SYSTEMS</i>	42
PRIMARY METALS PRODUCTION AND FABRICATION TECHNOLOGY	43
Primary Metalworking Technology	43
Metal-Forming Technology	44
Welding Technology	45
Oxyacetylene Welding	45
Arc Welding	46
Metal-Cutting Technology	46
Single-Point Tool Operations	47
Drilling and Allied Operations	47
Multipoint Tool Operations: Milling	47
Broaching	47
CHEMICAL PRODUCTION TECHNOLOGY	47
ELECTRONICS MANUFACTURING TECHNOLOGY	50
Silicon Germanium	50
Copper	50
III-V Semiconductors	50
III-V Consumables	51
Ultrapure Source Chemicals Technology	51
Supply, Handling and Management Technology	52
Bulk-Delivery Systems Technology	53
LASER TECHNOLOGY	54
Laser-Gas Composition	54

<b>TOPIC</b>	<b>PAGE NO.</b>
Laser-Gas Delivery	54
Laser-Gas Purity	54
FUEL CELLS	54
INTERNAL COMBUSTION ENGINES	55
HYDROGEN SENSORS	55
CHAPTER 5 MARKETS AND MARKETING	58
SUMMARY	58
TABLE 5 GLOBAL INDUSTRIAL GAS MARKET, THROUGH 2020 (\$ BILLIONS)	58
FIGURE 1 GLOBAL INDUSTRIAL GAS MARKET TRENDS, 2014-2020 (\$ BILLIONS)	58
INDUSTRIAL GAS MARKET BY END USER TYPE	59
TABLE 6 GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, THROUGH 2020 (\$ BILLIONS)	59
FIGURE 2 GLOBAL INDUSTRIAL GAS MARKET SHARE BY END-USER SEGMENT, 2014 VS. 2020 (%)	59
REFINING AND CHEMICAL PROCESSING	61
METAL MANUFACTURING AND FABRICATION	61
MEDICAL	61
FOOD AND BEVERAGE	61
ELECTRONICS	62
PULP AND PAPER	62
OTHER END-USE MARKET SEGMENTS	62
INDUSTRIAL GAS MARKET BY PRODUCT TYPE	63
TABLE 7 GLOBAL INDUSTRIAL GAS MARKET BY PRODUCT, THROUGH 2020 (\$ BILLIONS)	63
FIGURE 3 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PRODUCT, 2014 VS. 2020 (%)	63
OXYGEN	65
NITROGEN	65
SPECIALTY GASES	65
ARGON	66
HYDROGEN	66
CARBON DIOXIDE	66
RARE GASES	66
ACETYLENE	67
HELIUM	67
LIQUEFIED PETROLEUM GAS	67
SYNTHESIS GAS	67
OTHER	68
INDUSTRIAL GAS MARKET BY APPLICATION	68
NITROGEN	68
TABLE 8 GLOBAL NITROGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	69
FIGURE 4 GLOBAL NITROGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	69
Gaseous Nitrogen	71
Chemical Industry	71
Metal Production and Fabrication	71
Food Industry	71

<b>TOPIC</b>	<b>PAGE NO.</b>
Electrical Industry	71
Plastics Industry	71
Crude Oil Recovery and Refining	72
Research and Health Services	72
Construction	72
Glass Manufacturing	72
Liquid Nitrogen	72
Food Transportation	72
Medical	72
Electronics Industry	72
<b>OXYGEN</b>	73
<i>TABLE 9 GLOBAL OXYGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	73
<i>FIGURE 5 GLOBAL OXYGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	73
Primary Metals Manufacturing	75
Chemical Processing and Gasification	75
Clay, Glass and Concrete Products	75
Petroleum Refining	75
Welding and Cutting	76
Health Sciences	76
Pulp and Paper	76
Utilities	76
<b>HYDROGEN</b>	76
<i>TABLE 10 GLOBAL HYDROGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	77
<i>FIGURE 6 GLOBAL HYDROGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	77
Food	78
Chemical and Pharmaceutical Processing	78
Metal Production and Fabrication	78
Aerospace and Transportation	78
Electronics	78
Glass	79
Petroleum Refining	79
Water Treatment	79
Power Generation	79
Laboratory Research and Development	79
<b>ARGON</b>	79
<i>TABLE 11 GLOBAL ARGON MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	80
<i>FIGURE 7 GLOBAL ARGON MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	80
Inerting	81
Lighting	81
Electronics Manufacturing	82
Laboratory Research and Development	82
<b>CARBON DIOXIDE</b>	82
Liquid and Solid Carbon Dioxide	83
<i>TABLE 12 GLOBAL LIQUID AND SOLID CARBON DIOXIDE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	83
<i>FIGURE 8 GLOBAL LIQUID AND SOLID CARBON DIOXIDE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	83

<b>TOPIC</b>	<b>PAGE NO.</b>
Chemical Industry	85
Metal Industry	85
Plastics Industry	86
Food Industry	86
Pharmaceutical Industry	86
Beverage Industry	87
Medicine	87
Cleaning Systems	87
Oil and Gas Recovery	88
Other Industries	88
Gaseous CO <sub>2</sub>	88
<i>TABLE 13 GLOBAL GASEOUS CARBON DIOXIDE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	88
<i>FIGURE 9 GLOBAL GASEOUS CARBON DIOXIDE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	88
Firefighting	90
Agriculture	90
Enhanced Oil and Gas Recovery	90
SYNTHESIS GAS	90
<i>TABLE 14 GLOBAL SYNTHESIS GAS DEMAND BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	91
<i>FIGURE 10 GLOBAL SYNTHESIS GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	92
Chemicals and Fuels	93
Iron and Steel Production	93
Power Generation	93
Fischer-Tropsch Liquids	93
ACETYLENE	94
<i>TABLE 15 GLOBAL ACETYLENE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	94
<i>FIGURE 11 GLOBAL ACETYLENE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	94
HELIUM	95
<i>TABLE 16 GLOBAL HELIUM MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	96
<i>FIGURE 12 GLOBAL HELIUM MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	96
Optical Fibers	98
Shielding and Inerting	98
Drawing Process	98
Cooling Medium	98
Leak Tests	99
Weather Programs	99
Laboratory Research and Development	99
LIQUEFIED PETROLEUM GAS	100
<i>TABLE 17 GLOBAL LIQUEFIED PETROLEUM GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	100
<i>FIGURE 13 GLOBAL LIQUEFIED PETROLEUM GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	100
Industrial	102
Auto Fuel	102

<b>TOPIC</b>	<b>PAGE NO.</b>
Residential and Commercial	102
Chemical and Industrial	102
Other	102
<b>SPECIALTY INDUSTRIAL GASES</b>	102
<i>TABLE 18 GLOBAL SPECIALTY GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	103
<i>FIGURE 14 GLOBAL SPECIALTY GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	103
Electronics	105
Lasers	105
Medical	105
Lighting	105
Laboratory Research and Development	105
<b>RARE GASES</b>	106
<i>TABLE 19 GAS MIXTURES BY APPLICATION</i>	106
<i>TABLE 20 GLOBAL RARE GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)</i>	107
<i>FIGURE 15 GLOBAL RARE GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)</i>	107
Lighting	109
Medical	109
Laboratory Research and Development	109
<b>INDUSTRIAL GAS MARKET BY PRODUCTION TECHNOLOGY</b>	110
<i>TABLE 21 GLOBAL INDUSTRIAL GAS MARKET BY PRODUCTION TECHNOLOGY, THROUGH 2020 (\$ BILLIONS)</i>	110
<i>FIGURE 16 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PRODUCTION TECHNOLOGY, 2014 VS. 2020 (%)</i>	110
<b>CRYOGENIC AIR SEPARATION</b>	112
<b>VACUUM PRESSURE-SWING ADSORPTION</b>	112
<b>MEMBRANE TECHNOLOGY</b>	112
<b>REFORMING</b>	113
<b>GASIFICATION</b>	113
<b>MANUFACTURING BY-PRODUCTS</b>	114
Cement Production	114
Lime Production	114
Iron and Steel	114
<b>OTHER</b>	115
Chemical Reaction	115
Water Electrolysis	115
Natural Gas Processing	116
Recovery and Recycling	116
<b>INDUSTRIAL GAS MARKET BY PURITY GRADE</b>	116
<i>TABLE 22 GLOBAL INDUSTRIAL GAS MARKET BY PURITY GRADE, THROUGH 2020 (\$ BILLIONS)</i>	117
<i>FIGURE 17 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PURITY GRADE, 2014 VS. 2020 (%)</i>	117
<b>RESEARCH GRADE</b>	118
<b>ULTRA-HIGH-PURITY GRADE AND INSTRUMENT GRADE</b>	118
<b>HIGH-PURITY GRADE AND PROCESS GRADE</b>	118



<b>TOPIC</b>	<b>PAGE NO.</b>
CHAPTER 6 INDUSTRIAL GAS MARKET BY REGION	120
TABLE 23 GLOBAL INDUSTRIAL GAS MARKET BY REGION, THROUGH 2020 (\$ BILLIONS)	120
FIGURE 18 GLOBAL INDUSTRIAL GAS MARKET SHARE BY REGION, 2014 VS. 2020 (%)	120
EUROPE	122
NORTH AMERICA	122
ASIA-PACIFIC	122
INDUSTRIAL GAS MARKET BY DISTRIBUTION CHANNEL AND SUPPLY MODE	122
DISTRIBUTION CHANNELS	122
TABLE 24 GLOBAL INDUSTRIAL GAS MARKETS BY DISTRIBUTION CHANNEL, THROUGH 2020 (\$ BILLIONS)	122
FIGURE 19 GLOBAL INDUSTRIAL GAS MARKET SHARE BY DISTRIBUTION CHANNEL, 2014 VS. 2020 (%)	123
FIGURE 20 GLOBAL MARKET SHARE FOR DISTRIBUTORS OF INDUSTRIAL GASES BY REGION, 2014-2020 (%)	124
TABLE 25 GLOBAL INDUSTRIAL GAS SALES BY DISTRIBUTION CHANNEL AND REGION, THROUGH 2020 (\$ BILLIONS)	125
GAS SUPPLY MODES	125
TABLE 26 GLOBAL INDUSTRIAL GAS MARKET SHARE BY SUPPLY MODE, 2014-2020 (%)	126
PACKAGED CYLINDERS	126
BULK SHIPMENTS	126
ON-SITE PLANTS AND PIPELINES	127
MARKETING	127
SUPPORT SERVICES	127
Cylinder-Management and Logistics Systems	127
Applications Training	128
Compliance Management	128
e-Business	128
CHAPTER 7 GOVERNMENT REGULATIONS AND LEGISLATION	130
INTRODUCTION	130
U.S.	130
FEDERAL INITIATIVES	130
Department of Energy	130
FIGURE 21 U.S. DEPARTMENT OF ENERGY HYDROGEN AND FUEL CELL FUNDING, FY2004-FY2014 (\$ MILLIONS)	130
FIGURE 22 OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY HYDROGEN BUDGET, FY2014 (%)	131
Other U.S. Government Programs and Initiatives	132
STATE INITIATIVES	132
California	132
New York	133
Other States	134
EUROPEAN UNION	134
EU PROGRAMS	134
Fuel Cells and Hydrogen Joint Undertaking	134

<b>TOPIC</b>	<b>PAGE NO.</b>
<i>FIGURE 23 GLOBAL MARKET SHARE OF JOINT UNDERTAKING HYDROGEN INVESTMENTS BY AREA, 2008-2013 (%)</i>	134
Dioxide Emissions Restrictions	135
EU MEMBER STATES	136
Germany	136
France	136
Italy	137
Denmark	137
JAPAN	138
CHINA	138
INDIA	138
OTHER COUNTRIES	139
INTERGOVERNMENTAL PROGRAMS	139
U.S.-EU COLLABORATION	139
INTERNATIONAL PARTNERSHIP FOR THE HYDROGEN ECONOMY	140
INTERNATIONAL ENERGY AGENCY HYDROGEN COORDINATION GROUP	140
CHAPTER 8 INDUSTRIAL GAS HEALTH AND SAFETY ISSUES	142
INDUSTRIAL GAS HEALTH AND SAFETY ISSUES	142
INDUSTRIAL GAS TRAINING COURSES FOR INDUSTRIAL SECTORS	143
SAFETY	144
OCCUPATIONAL HEALTH AND HYGIENE	144
ENVIRONMENT	144
QUALITY	144
CHAPTER 9 INDUSTRY STRUCTURE	147
INDUSTRY STRUCTURE AND CHARACTERISTICS	147
NUMBER AND SIZE OF FIRMS	147
LEADING FIRMS	147
<i>FIGURE 24 GLOBAL INDUSTRIAL GAS MARKET BY LEADING SUPPLIERS, 2014 (\$ BILLIONS)</i>	147
L' Air Liquide	148
Linde AG	148
Praxair	148
Air Products	148
Airgas Inc.	149
Taiyo Nippon Sanso	149
Messer Group GmbH	149
OWNERSHIP TRENDS	150
CHAPTER 10 PATENT ANALYSIS	152
<i>TABLE 27 U.S. PATENT AWARDS FOR INDUSTRIAL GAS-PROCESS TECHNOLOGIES, 2010-2014 (NO. OF PATENTS)</i>	152
<i>FIGURE 25 U.S. PATENT AWARD TRENDS FOR INDUSTRIAL GAS PROCESS TECHNOLOGIES, 2010-2014 (NO. OF PATENTS)</i>	152
CHAPTER 11 COMPANY PROFILES	155
COMPONENT AND EQUIPMENT MANUFACTURERS	155

<b>TOPIC</b>	<b>PAGE NO.</b>
ATLAS COPCO	155
CHICAGO BRIDGE & IRON CO. N.V.	155
FABRICATION AND CONSTRUCTION	155
TECHNIP	155
ENABLING TECHNOLOGIES PROVIDERS	156
XEBEC ADSORPTION INC.	156
LICENSORS, CONTRACTORS AND OPERATORS	156
DIVERSIFIED ENERGY CORP.	156
ENGINEERED GAS SYSTEMS LLP	157
HALDOR TOPSOE A/S	157
SIEMENS AG	157
THYSSENKRUPP INDUSTRIAL SOLUTIONS	158
UNIVERSAL INDUSTRIAL GASES INC.	158
PRODUCERS AND DISTRIBUTORS	159
AIR LIQUIDE AMERICA SPECIALTY GASES LLC.	159
AIR PRODUCTS AND CHEMICALS INC.	159
AIR WATER INC.	160
AIRGAS INC.	160
ALEXANDER CHEMICAL CORP.	160
AMERICAN GAS GROUP	160
CARBUROS METALICOS S.A.	161
FOSTER WHEELER CORP.	161
L'AIR LIQUIDE SA	161
LINDE AG	162
MESSER GROUP GMBH	162
MITSUBISHI GAS CHEMICAL CO.	162
NUCO2 INC.	162
OZONO ELECTRONICA INTERNATIONALE SRL	163
PRAXAIR INC.	163
REGO PRODUCTS	163
SCOTTISH CHEMICAL INDUSTRIES	163
SERVOMEX GROUP LTD.	164
SHOWA DENKO GAS PRODUCTS CO. LTD.	164
SPECIAL GAS SERVICES INC.	164
TAIYO NIPPON SANSO CORP.	164
TAIYO TOYO SANSO CO. LTD.	165
TOLL GAS AND WELDING SUPPLY	165
UTTAM AIR PRODUCTS PVT. LTD.	165
VOLTAIX INC.	165
MANUFACTURERS OF FUEL CELLS AND COMPONENTS	166
BALLARD POWER SYSTEMS	166
FUEL CELL ENERGY INC.	166
HYDROGENICS CORP.	167
PLUG POWER LLC	167
PROTON ONSITE	167

**LIST OF TABLES**

<b>TABLE HEADING</b>	<b>PAGE NO.</b>
SUMMARY TABLE GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, THROUGH 2020 (\$ BILLIONS)	8
TABLE 1 PRESSURE AND TEMPERATURE DATA FOR VARIOUS CRYOGENIC INDUSTRIAL GASES	22
TABLE 2 TECHNICAL-GRADE INDUSTRIAL GAS PRODUCTION TECHNOLOGIES	30
TABLE 3 AIR-SEPARATION TECHNOLOGY COMPARISON: CRYOGENIC VERSUS NONCRYOGENIC PROCESSES	30
TABLE 4 HYDROTREATING REACTIONS OF DIFFERENT REFINERY SYSTEMS	42
TABLE 5 GLOBAL INDUSTRIAL GAS MARKET, THROUGH 2020 (\$ BILLIONS)	58
TABLE 6 GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, THROUGH 2020 (\$ BILLIONS)	59
TABLE 7 GLOBAL INDUSTRIAL GAS MARKET BY PRODUCT, THROUGH 2020 (\$ BILLIONS)	63
TABLE 8 GLOBAL NITROGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	69
TABLE 9 GLOBAL OXYGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	73
TABLE 10 GLOBAL HYDROGEN MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	77
TABLE 11 GLOBAL ARGON MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	80
TABLE 12 GLOBAL LIQUID AND SOLID CARBON DIOXIDE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	83
TABLE 13 GLOBAL GASEOUS CARBON DIOXIDE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	88
TABLE 14 GLOBAL SYNTHESIS GAS DEMAND BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	91
TABLE 15 GLOBAL ACETYLENE MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	94
TABLE 16 GLOBAL HELIUM MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	96
TABLE 17 GLOBAL LIQUEFIED PETROLEUM GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	100
TABLE 18 GLOBAL SPECIALTY GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	103
TABLE 19 GAS MIXTURES BY APPLICATION	106
TABLE 20 GLOBAL RARE GAS MARKET BY APPLICATION, THROUGH 2020 (\$ BILLIONS)	107
TABLE 21 GLOBAL INDUSTRIAL GAS MARKET BY PRODUCTION TECHNOLOGY, THROUGH 2020 (\$ BILLIONS)	110
TABLE 22 GLOBAL INDUSTRIAL GAS MARKET BY PURITY GRADE, THROUGH 2020 (\$ BILLIONS)	117
TABLE 23 GLOBAL INDUSTRIAL GAS MARKET BY REGION, THROUGH 2020 (\$ BILLIONS)	120
TABLE 24 GLOBAL INDUSTRIAL GAS MARKETS BY DISTRIBUTION CHANNEL, THROUGH 2020 (\$ BILLIONS)	122
TABLE 25 GLOBAL INDUSTRIAL GAS SALES BY DISTRIBUTION CHANNEL AND REGION, THROUGH 2020 (\$ BILLIONS)	125
TABLE 26 GLOBAL INDUSTRIAL GAS MARKET SHARE BY SUPPLY MODE, 2014-2020 (%)	126
TABLE 27 U.S. PATENT AWARDS FOR INDUSTRIAL GAS-PROCESS TECHNOLOGIES, 2010-2014 (NO. OF PATENTS)	152

**LIST OF FIGURES**

<b>FIGURE TITLE</b>	<b>PAGE NO.</b>
SUMMARY FIGURE GLOBAL INDUSTRIAL GAS MARKET BY END-USE SEGMENT, 2014-2020 (\$ BILLIONS)	8
FIGURE 1 GLOBAL INDUSTRIAL GAS MARKET TRENDS, 2014-2020 (\$ BILLIONS)	58
FIGURE 2 GLOBAL INDUSTRIAL GAS MARKET SHARE BY END-USER SEGMENT, 2014 VS. 2020 (%)	59
FIGURE 3 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PRODUCT, 2014 VS. 2020 (%)	63
FIGURE 4 GLOBAL NITROGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	69
FIGURE 5 GLOBAL OXYGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	73
FIGURE 6 GLOBAL HYDROGEN MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	77
FIGURE 7 GLOBAL ARGON MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	80
FIGURE 8 GLOBAL LIQUID AND SOLID CARBON DIOXIDE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	83
FIGURE 9 GLOBAL GASEOUS CARBON DIOXIDE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	88
FIGURE 10 GLOBAL SYNTHESIS GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	92
FIGURE 11 GLOBAL ACETYLENE MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	94
FIGURE 12 GLOBAL HELIUM MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	96
FIGURE 13 GLOBAL LIQUEFIED PETROLEUM GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	100
FIGURE 14 GLOBAL SPECIALTY GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	103
FIGURE 15 GLOBAL RARE GAS MARKET SHARE BY APPLICATION, 2014 VS. 2020 (%)	107
FIGURE 16 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PRODUCTION TECHNOLOGY, 2014 VS. 2020 (%)	110
FIGURE 17 GLOBAL INDUSTRIAL GAS MARKET SHARE BY PURITY GRADE, 2014 VS. 2020 (%)	117
FIGURE 18 GLOBAL INDUSTRIAL GAS MARKET SHARE BY REGION, 2014 VS. 2020 (%)	120
FIGURE 19 GLOBAL INDUSTRIAL GAS MARKET SHARE BY DISTRIBUTION CHANNEL, 2014 VS. 2020 (%)	123
FIGURE 20 GLOBAL MARKET SHARE FOR DISTRIBUTORS OF INDUSTRIAL GASES BY REGION, 2014-2020 (%)	124
FIGURE 21 U.S. DEPARTMENT OF ENERGY HYDROGEN AND FUEL CELL FUNDING, FY2004-FY2014 (\$ MILLIONS)	130
FIGURE 22 OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY HYDROGEN BUDGET, FY2014 (%)	131
FIGURE 23 GLOBAL MARKET SHARE OF JOINT UNDERTAKING HYDROGEN INVESTMENTS BY AREA, 2008-2013 (%)	134
FIGURE 24 GLOBAL INDUSTRIAL GAS MARKET BY LEADING SUPPLIERS, 2014 (\$ BILLIONS)	147
FIGURE 25 U.S. PATENT AWARD TRENDS FOR INDUSTRIAL GAS PROCESS TECHNOLOGIES, 2010-2014 (NO. OF PATENTS)	152