World Hydrogen

Industry Study with Forecasts for 2016 & 2021

Study #2895 | July 2012 | $5900 | 345 pages
Table of Contents

EXECUTIVE SUMMARY

MARKET ENVIRONMENT
General .................................................. 4
World Economic Overview ......................... 6
Recent Historical Trends ............................ 6
World Economic Outlook ......................... 8
World Population Overview ....................... 12
World Manufacturing Overview .................. 14
World Chemical Manufacturing Outlook ...... 16
World Energy Outlook ............................ 18
World Petroleum Refining Outlook ........... 22
World Fuel Cell Outlook ......................... 25
World Motor Vehicle Outlook .................. 29
Hydrogen-Powered Motor Vehicles .......... 32
Hydrogen Fuel Cell Vehicles ..................... 33
Hydrogen Internal Combustion Engine Vehicles ... 35
Environmental & Regulatory Issues ........... 36
Codes & Standards ................................. 40

WORLD HYDROGEN OVERVIEW
General .................................................. 42
World Hydrogen Demand by Region .......... 46
World Hydrogen Demand by Market .......... 51
Petroleum Refining ................................ 53
Petroleum Refining Processes ................. 56
Chemical Manufacturing ....................... 58
Other Markets for Hydrogen .................. 61
Manufacturing ...................................... 63
All Other ............................................. 66
The Hydrogen Economy .......................... 67
General ............................................... 68
Fuel Cells ........................................... 70
Electric Power Generation .................... 72
Motor Vehicles .................................... 73
Other Transportation Equipment .......... 74
Industrial Stationary & Motive Power 74
Portable Electronics ............................ 75
Other ................................................... 76
Hydrogen Production Methods ............... 77
Hydrogen from Hydrocarbons ................. 77
Hydrogen from Water ......................... 79
Hydrogen from Other Sources ............... 81
Hydrogen Storage ............................... 82
Pricing Trends ...................................... 85

NORTH AMERICA
Macroeconomic Environment ................ 87
Hydrogen Demand ................................. 90
Suppliers & Market Share ...................... 92
United States ........................................ 94
Canada ............................................... 104
Mexico ............................................... 111

WESTERN EUROPE
Macroeconomic Environment ................. 119
Hydrogen Demand ................................. 122
Suppliers & Market Share ....................... 126
Germany ............................................. 128
Italy .................................................. 137
France .............................................. 144
United Kingdom .................................... 150
The Netherlands ................................... 157
Spain .................................................. 164
Other Western Europe ............................ 170

ASIA/PACIFIC
Macroeconomic Environment ................. 179
Hydrogen Demand ................................. 183
Suppliers & Market Share ....................... 186
China ............................................... 190
Japan .............................................. 199
India ............................................... 209
South Korea ....................................... 217
Taiwan ............................................. 225
Australia .......................................... 231
Other Asia/Pacific ................................. 238

OTHER REGIONS
Central & South America ....................... 244
Macroeconomic Environment ................. 244
Hydrogen Demand ................................. 247
Suppliers & Market Share ....................... 249
Brazil ............................................... 251
Other Central & South America ............ 257
Eastern Europe .................................... 263
Macroeconomic Environment ................. 263
Hydrogen Demand ................................. 267
Suppliers & Market Share ....................... 269
Russia .............................................. 271
Other Eastern Europe ............................ 278
Africa/Mideast ...................................... 284
Macroeconomic Environment ................. 284
Hydrogen Demand ................................. 288
Suppliers & Market Share ....................... 292

INDUSTRY STRUCTURE
General .............................................. 295
Market Share ....................................... 297
Acquisitions & Divestitures .................. 302
Cooperative Agreements ..................... 303
Distribution ....................................... 307

COMPANY PROFILES
Air Liquide .......................................... 312
Air Products and Chemicals ................. 316
Airgas Incorporated ............................... 323
Iwatani International ............................ 325
Linde Group ........................................ 327
Messer Group ....................................... 333
Praxair Incorporated ............................. 335
Showa Denko ....................................... 341
Taiyo Nippon Sanso .............................. 342

List of Tables/Charts

EXECUTIVE SUMMARY
1 Summary Table ................................... 3

MARKET ENVIRONMENT
1 World Gross Domestic Product by Region .... 12
2 World Population by Region ..................... 14
3 World Manufacturing Value Added by Region .... 16
4 World Chemical Manufacturing Value Added by Region .... 18
5 World Energy Production by Type ............. 21
Cht World Energy Production by Type, 2001-2021 .......... 21
6 World Refined Petroleum Products Production by Region .... 25
7 World Commercial Fuel Cell Demand by Region .... 28
Cht World Commercial Fuel Cell Demand by Region, 2011 ........ 29
8 World Motor Vehicle Production by Region .... 32
9 World Commercial Motor Vehicle Fuel Cell Demand by Chemistry, Region, & Product .... 35

WORLD HYDROGEN OVERVIEW
1 World Hydrogen Demand ....................... 46
2 World Hydrogen Demand by Region .......... 49
Cht World Hydrogen Demand by Region, 2011 .......... 50

(continued on following page)
List of Tables/Charts

(continued from previous page)

Cht Share of Market Growth by Region, 2011-2016.............. 50
3 World Hydrogen Demand by Market.. 52
Cht World Hydrogen Demand by Country, 2011............. 53
4 World Petroleum Refining Market for Hydrogen by Application & Source 58
5 World Chemical Manufacturing Market for Hydrogen ............ 60
7 Other Global Markets for Hydrogen by Region & Type ....... 62
8 World Commercial Fuel Cell Demand by Application .......... 72
9 Hydrogen Pricing & Valuation .......... 86

NORTH AMERICA
1 North America: Market Environment for Hydrogen .......... 89
2 North America: Hydrogen Demand by Market.............. 91
Cht North America: Hydrogen Demand by Country, 2011........ 92
3 United States: Market Environment for Hydrogen .......... 98
4 United States: Hydrogen Demand by Market.................. 101
5 Canada: Market Environment for Hydrogen .................. 107
6 Canada: Hydrogen Demand by Market....................... 109
7 Mexico: Market Environment for Hydrogen .................. 115
8 Mexico: Hydrogen Demand by Market....................... 118

WESTERN EUROPE
1 Western Europe: Market Environment for Hydrogen ....... 122
2 Western Europe: Hydrogen Demand by Market............. 125
Cht Western Europe Hydrogen Demand by Country, 2011 ...... 126
Cht Western Europe: Merchant Market Share, 2011 .......... 128
3 Germany: Market Environment for Hydrogen ................. 131

ASIA/PACIFIC
1 Asia/Pacific: Market Environment for Hydrogen ............ 134
5 Italy: Market Environment for Hydrogen .................... 140
6 Italy: Hydrogen Demand by Market 142
7 France: Market Environment for Hydrogen .................. 147
8 France: Hydrogen Demand by Market...................... 149
9 United Kingdom: Market Environment for Hydrogen .......... 153
10 United Kingdom: Hydrogen Demand by Market............ 155
11 Netherlands: Market Environment for Hydrogen .......... 160
12 Netherlands: Hydrogen Demand by Market................ 162
13 Spain: Market Environment for Hydrogen .................. 167
14 Spain: Hydrogen Demand by Market169
15 Other Western Europe: Market Environment for Hydrogen .... 173
16 Other Western Europe: Hydrogen Demand by Market........ 175

14 Australia: Hydrogen Demand by Market..................... 236
15 Other Asia/Pacific: Market Environment for Hydrogen ...... 241
16 Other Asia/Pacific: Hydrogen Demand by Market............ 243

OTHER REGIONS
1 Central & South America: Market Environment for Hydrogen .... 247
2 Central & South America: Hydrogen Demand by Market........ 249
Cht Central & South America: Merchant Hydrogen Market Share, 2011.... 251
3 Brazil: Market Environment for Hydrogen .................... 254
4 Brazil: Hydrogen Demand by Market.......................... 256
5 Other Central & South America: Market Environment for Hydrogen 260
6 Other Central & South America: Hydrogen Demand by Market & Country .......... 263
7 Eastern Europe: Market Environment for Hydrogen .......... 267
8 Eastern Europe: Hydrogen Demand by Market................. 269
Cht Eastern Europe: Merchant Hydrogen Market Share, 2011...... 271
9 Russia: Market Environment for Hydrogen .................... 274
10 Russia: Hydrogen Demand by Market........................ 276
11 Other Eastern Europe: Market Environment for Hydrogen .... 281
12 Other Eastern Europe: Hydrogen Demand by Market & Country .... 284
13 Africa/Mideast: Market Environment for Hydrogen .......... 288
14 Africa/Mideast: Hydrogen Demand by Market & Country .... 292
Cht Africa/Mideast: Merchant Hydrogen Market Share, 2011..... 294

INDUSTRY STRUCTURE
1 Merchant Hydrogen Sales by Company, 2011.................. 297
2 Selected Acquisitions & Divestitures......................... 303
3 Selected Cooperative Agreements.. 305
Cht World Merchant Hydrogen Market Share, 2011............... 299

Click here to purchase online

Order now, click here!
The Asia/Pacific region has supplanted North America as the leading hydrogen consumer, as demand is driven by the low-sulfur, cleaner burning fuels from the petroleum refining industry.

World demand to rise over 4% yearly through 2016

Global demand for hydrogen is projected to increase 4.1 percent annually through 2016 to 286 billion cubic meters, valued at $43.2 billion. The primary driver of this growth will be the petroleum refining industry, whose hydrogen consumption is driven mainly by the production of low-sulfur, cleaner burning fuels. Though approximately 90 percent of this consumed hydrogen is captive production liberated by oil refining processes, the balance is merchant hydrogen, usually generated by steam methane reformers.

Various countries and regions around the world have legislated carbon dioxide emission limits from the burning of hydrocarbon fuels. These are generally becoming more stringent, and as they are enacted and enforced, additional hydrogen is needed to hydrotreat petroleum to yield cleaner fuels that meet emission regulations. Also adding to hydrogen demand is the fact that the quality of crude oil feedstocks is gradually declining, leaving higher sulfur crudes that require more hydrogen to be refined.

Chemical manufacturing a large hydrogen market

Chemical manufacturing is the second largest consumer of hydrogen. Some hydrogen used by chemical and petrochemical producers is generated from process off-gas, though most is supplied by dedicated on-site hydrogen plants or purchased from merchant suppliers. In general, manufacturing and other applications, the production of semiconductors and float glass, the thermal treatment of metal components, and the hydrogenation of processed foods are the largest consumers of hydrogen.

Asia/Pacific region now world’s largest consumer

Whereas North America led the world in hydrogen consumption in 2006, rapid growth of many national economies in the Asia/Pacific region -- especially those of China and India -- made the Asia/Pacific region the world’s largest hydrogen consumer in 2011. Western Europe is third among the world’s hydrogen consumers. Hydrogen consumption in Central and South America will be led by Brazil; in Eastern Europe by the economies of Russia, Ukraine, and Poland; and in the Africa/Mideast region by the oil-rich nations of Saudi Arabia and Iran.

The movement aimed at promoting hydrogen as an energy carrier and reducing emissions produced by the consumption of hydrocarbon fuels is often referred to as the “hydrogen economy.” Most of the world’s leading economies have financed, through public and private sectors, the ongoing development of technologies (such as fuel cells developed for motor vehicles and power generation), infrastructures, and safety codes relating to hydrogen energy. Germany, Japan and the US lead the world in commercial fuel cell demand and R&D investment. Though the hydrogen economy is slowly becoming a reality, its true promise is still decades away.
Asia/Pacific

China: Hydrogen Demand

Between 2001 and 2011, China’s consumption of hydrogen more than tripled, to 31.4 billion cubic meters valued at $4.3 billion -- the result of spectacular growth in all the country’s key hydrogen consuming sectors. Growth in these sectors will remain healthy, further driving hydrogen demand to 48.0 billion cubic meters in 2016, valued at $8 billion. By 2016, China will account for 39 percent of regional hydrogen consumption. China will account for 60 percent of the Asia/Pacific region’s incremental hydrogen demand, and 32 percent of the world’s.

In 2011, China consumed 18 billion cubic meters of hydrogen for refineries. Refinery consumption in the country is projected to advance 9.2 percent annually from 2011 to 2016. The rapid growth in China’s refinery capacity will drive these world-leading gains, as will investment in refinery upgrades designed to broaden the range of crude oils the country can import. Chinese refiners are investing in hydrocracking, catalytic cracking, and alkylation units to maximize their output of high-value motor fuels. Also, increased used of hydrotreating will help drive hydrogen demand as Chinese authorities step up their campaign to improve air quality by reducing sulfur levels in motor vehicle fuels. China’s aggressive investment in oil infrastructure and refining capacity supports a long term strategy of making it a world-player in energy markets. The nation is also investing in petroleum infrastructure abroad in partnership with OPEC suppliers of petroleum.

Chemical manufacturing in China accounted for 28 percent of the nation’s hydrogen consumption in 2011 -- a very large share compared to that in other countries. Relative to world hydrogen consumption, which chemical production accounts for an average of 12 percent, China’s 28 percent is indicative of its status as the world’s largest chemical producer.

### Table VI-3

**China: Market Environment for Hydrogen**

<table>
<thead>
<tr>
<th>Item</th>
<th>2001</th>
<th>2006</th>
<th>2011</th>
<th>2016</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (mil persons)</td>
<td>1273</td>
<td>1310</td>
<td>1344</td>
<td>1376</td>
<td>1402</td>
</tr>
<tr>
<td>GDP/capita</td>
<td>3180</td>
<td>5120</td>
<td>8220</td>
<td>11900</td>
<td>16620</td>
</tr>
<tr>
<td>Gross Domestic Product (bil 2010$)</td>
<td>4045</td>
<td>6705</td>
<td>11050</td>
<td>16370</td>
<td>23300</td>
</tr>
<tr>
<td>cubic meters gas/capita</td>
<td>8</td>
<td>13</td>
<td>23</td>
<td>35</td>
<td>46</td>
</tr>
<tr>
<td>cubic meters gas/000$ GDP</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>2.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Refined Petro Prdts (mil metric tons)</td>
<td>213</td>
<td>299</td>
<td>405</td>
<td>622</td>
<td>751</td>
</tr>
<tr>
<td>Chemical MVA (bil 2010$)</td>
<td>127</td>
<td>213</td>
<td>405</td>
<td>600</td>
<td>857</td>
</tr>
<tr>
<td>Manufacturing Value-Added (bil 2010$)</td>
<td>959</td>
<td>1887</td>
<td>3640</td>
<td>5660</td>
<td>8260</td>
</tr>
<tr>
<td>Commercial Fuel Cell Demand (mil $)</td>
<td>1</td>
<td>7</td>
<td>15</td>
<td>110</td>
<td>670</td>
</tr>
<tr>
<td>Hydrogen Demand (bil cubic meters)</td>
<td>9.7</td>
<td>17.6</td>
<td>31.4</td>
<td>48.0</td>
<td>64.9</td>
</tr>
<tr>
<td>% China</td>
<td>23.6</td>
<td>29.9</td>
<td>39.2</td>
<td>44.4</td>
<td>47.9</td>
</tr>
<tr>
<td>Asia/Pacific Hydrogen Dmnd (bil cu m)</td>
<td>41.1</td>
<td>58.9</td>
<td>80.2</td>
<td>108.0</td>
<td>135.5</td>
</tr>
</tbody>
</table>

### Chart VII-2

**Eastern Europe: Merchant Hydrogen Market Share**

(3.6 billion cubic meters, 2011)

- Germany: 31.5%
- Germany: 21.8%
- Other: 20.0%
- Other: 8.9%
- Other: 3.6%


**COMPANY PROFILES**

**Messer Group GmbH**
Messer-Platz 1
65812 Bad Soden
Germany
49-6196 7760
http://www.messergroup.com

Sales: $1.4 billion (2011, as reported by company)
Geographic Sales: Western Europe 30%, South Eastern Europe 17%, Central Europe 19%, China 30%, and Other 4%
Employment: 5,250 (2011, as reported by company)

Key Products: hydrogen for thermal spraying, plasma arc cutting, glass polishing, carburization, food and other applications

Messer Group produces, supplies, and distributes industrial gases and related equipment for the wastewater, electrical, electronics, health services, food and beverage, glass, ceramics, metal goods, automotive, petrochemical, rubber and plastics industries. The privately held company is owned by the Messer family. In September 2011, the Company moved its headquarters from Sulzbach to Bad Soden, Germany.

The Company competes in the world hydrogen industry through the manufacture of hydrogen and a wide range of other gases for thermal spraying, plasma arc cutting, glass polishing, carburization, food, and other applications. Thermal spraying hydrogen is used primarily in the automotive, aviation, mechanical engineering, mining, and trade industries. The thermal spraying process is used to protect base metals, including steel, from corrosion, wear, and heat damage. Messer Group’s plasma arc cutting hydrogen gas is used to raise cutting speed, reduce metal waste and distortion, and provide clean cut surfaces.

“Although China’s chemical industry is evolving toward greater production of specialty chemicals, the nation will remain a leading global source of both organic and inorganic chemicals. This will drive gains in hydrogen demand to 13.1 billion cubic meters in 2016 on annual growth of 8.0 percent. Linde, for example, announced in late 2011 that it will build and operate a new hydrogen plant in the Jilin Chemical Industrial Park in China’s northeast region.”

--Section VI, pg. 195
Order Information
Five Convenient Ways to Order

ONLINE: www.freedoniagroup.com
MAIL: Print out and complete the order form and send to The Freedonia Group
(see address at the bottom of this form)
PHONE: Call toll free, 800.927.5900 (US) or +1 440.684.9600
FAX: +1 440.646.0484 (US)
EMAIL: info@freedoniagroup.com

Free Handling & Shipping
There is NO charge for handling or UPS shipping in the US. Expect delivery in 3 to 5 business days. Outside the US, Freedonia provides free airmail service. Express delivery is available at cost.

Orders Outside of the US
Checks must be made payable in US funds, drawn against a US bank and mailed directly to The Freedonia Group. For wire transfers please contact our customer service department at info@freedoniagroup.com. Credit cards accepted.

Corporate Use License
Now every decision maker in your organization can act on the key intelligence found in all Freedonia studies. For an additional $2600, companies receive unlimited use of an electronic version (PDF) of the study. Place it on your intranet, e-mail it to coworkers around the world, or print it as many times as you like.

Order Form

World Hydrogen ............................................................ $5900

☐ Corporate Use License (add to study price) *
☐ Additional Print Copies @ $600 each *

Total (including selected option) $____________________

☐ Enclosed is my check (5% discount) drawn on a US bank and payable to The Freedonia Group, Inc., in US funds (Ohio residents add 7.75% sales tax)

☐ Bill my company ☐ American Express ☐ MasterCard ☐ Visa

Credit Card # ________________________ Expiration Date MM YY

Name ____________________________
Title ____________________________
Company _________________________
Division _________________________
Street ____________________________
(No PO Box please)
City/State/Zip _____________________
Country _________________________
Phone ____________________________ Fax _________________________
Email ____________________________

☐ Individual Use License Agreement
The undersigned hereby represents that the above captioned study will be used by only __ individual(s) who are employees of the company and that the study will not be loaded on a network for multiple users. In the event that usage of the study changes, the Company will promptly notify Freedonia of such change and will pay to Freedonia the appropriate fee based on Freedonia’s standard fee schedule then in effect. Note: Entire company corporate use license, add $2600; one additional user, add $600; two additional users, add $1200; three additional users, add $1800.

☐ Corporate Use License Agreement
The above captioned study may be stored on the company’s intranet or shared directory, available to company employees. Copies of the study may be made, but the undersigned represents that distribution of the study will be limited to employees of the company.

Signature ____________________________

Please check appropriate option and sign below to order an electronic version of the study.

Save 15%
If you order three (3) different titles at the same time, you can receive a 15% discount. If your order is accompanied by a check or wire transfer, you may take a 5% cash discount (discounts do not apply to Corporate Use Licenses).
About The Freedonia Group

The Freedonia Group, Inc., is a leading international industry market research company that provides its clients with information and analysis needed to make informed strategic decisions for their businesses. Studies help clients identify business opportunities, develop strategies, make investment decisions and evaluate opportunities and threats. Freedonia research is designed to deliver unbiased views and reliable outlooks to assist clients in making the right decisions. Freedonia capitalizes on the resources of its proprietary in-house research team of experienced economists, professional analysts, industry researchers and editorial groups. Freedonia covers a diverse group of industries throughout the United States, the emerging China market, and other world markets. Industries analyzed by Freedonia include:

- Chemicals
- Plastics
- Life Sciences
- Packaging
- Building Materials
- Security & Electronics
- Industrial Components & Equipment
- Automotive & Transportation Equipment
- Household Goods
- Energy/Power Equipment

Freedonia Custom Research

Freedonia Custom Research delivers the same high quality, thorough and unbiased assessment of an industry or market as an industry study. Since the research initiative is based upon a company’s specific needs, companies harness Freedonia’s research capabilities and resources to answer unique questions. When you leverage the results of a Freedonia Custom Research engagement, you are able to obtain important answers to specific questions and issues associated with: mergers and acquisitions, new product launches/development, geographic expansion, entry into new markets, strategic business planning, and investment and funding decisions.

Freedonia Custom Research is ideal for companies seeking to make a strategic difference in the status quo and focus on future business growth. Working side by side with clients, Freedonia’s team is able to define a research project that is custom-tailored to answer specific questions and provide the basis from which a company can make informed business decisions.

Click here for complete title list

Click here to visit freedoniagroup.com

The Freedonia Group, Inc. 767 Beta Drive • Cleveland, OH • 44143-2326 • USA • Web site: www.freedoniagroup.com
Tel US: 800.927.5900 or +1 440.684.9600 • Fax: +1 440.646.0484 • e-mail: info@freedoniagroup.com