World Hydrogen

Industry Study with Forecasts for 2018 & 2023

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World demand to rise 3.5% annually through 2018

World consumption of captive and merchant hydrogen is projected to increase 3.5 percent annually through 2018 to more than 300 billion cubic meters, driven by increasing use in refinery hydroprocessing, especially in developing countries in Asia. These advances will result from rising per capita vehicle ownership rates and clean fuel regulations enacted to address increasingly pressing environmental and pollution concerns. The merchant market for hydrogen will expand more than five percent annually as the need for hydrogen in petroleum refineries exceeds refiners’ available captive resources.

Refining to remain key market for hydrogen

Over the past two decades, the adoption of motor vehicle emissions regulations by developed countries has led to the need for low-sulfur and ultra-low sulfur gasoline and diesel fuels, greatly increasing the consumption of hydrogen in petroleum refining. This trend will continue to drive demand going forward as developing countries address air quality issues by enforcing more stringent clean fuel regulations. The broadening of these regulations to encompass marine and other off-highway fuels will further support growth. Growth in developing countries will also be aided by rising per capita vehicle ownership rates and higher demand for fuels.

Additionally, both the shift in the world’s crude oil supply toward heavier, lower quality crudes and rising demand for distillate fuels globally will support the increased use of hydrogen in refining.

Outside of refining, hydrogen is used in the production of many important chemicals as well as in the metals, electronics, and thin-film solar industries; edible oil processing; and a variety of other applications. Additionally, the adoption of hydrogen energy technologies continues to proceed worldwide, and fuel cells will see increasing mainstream commercial use. Despite technical challenges, the emergence of a hydrogen market for fuel cell powered vehicles remains a possibility.

China to see greatest share of growth through 2018

Although the United States will remain the world’s largest hydrogen market in volume terms, the greatest share of growth through 2018 is expected to occur in China. The country is expected to aggressively target motor vehicle emissions by enacting and enforcing tighter clean fuel regulations. This will drive hydrogen demand growth as the country’s refining industry modernizes and increases its ability to produce low-sulfur fuels. In other emerging markets, countries such as India and Russia will also seek to export ultra-low sulfur fuels and will see among the fastest gains.
**OTHER REGIONS**

**Petroleum Refining:** Refinery hydrogen consumption is forecast to more than double between 2013 and 2018, rising from 710 million cubic meters to 1.5 billion cubic meters. This rapid growth will come from the addition of substantial hydroprocessing capacity at the country’s refineries, including both new refineries and upgrades to existing facilities. The country’s total refined product output is expected to rise supported by healthy domestic demand.

Brazil’s refineries, the large majority of which are operated by Petrobras, are primarily focused on crude distillation with minimal capacity in conversion or treatment processes (e.g., hydrocracking and hydrotreating). Because Brazil is expected to tighten its fuel sulfur regulations, it will need to significantly boost its hydrotreating capacity. Additionally, with the bulk of the country’s crude oil coming from domestic production of heavy oil, the refining industry’s profitability will depend on adding cracking capacity to enable it to produce high value fuels from this heavy feedstock.

**Other Markets:** Brazil’s growing presence as a global manufacturer of chemicals has driven significant growth in hydrogen use in the chemical industry. Hydrogen consumption is forecast to further rise from 620 million cubic meters in 2013 to 750 million cubic meters in 2018, increasing at a seven percent annual growth rate. Brazil uses hydrogen primarily for conversion processes.

Although Brazil has seen minimal demand for fuel cells and other hydrogen energy related technologies thus far, the country has a strong position in bio-based fuels (e.g., ethanol) and other “green” chemicals. Several theoretical processes are being explored which could develop into renewable hydrogen production from biomass at commercial scale.

**Sample Text, Table & Chart**

### TABLE VI-3
**GERMANY: MARKET ENVIRONMENT FOR HYDROGEN**

<table>
<thead>
<tr>
<th>Item</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2018</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (mil persons)</td>
<td>82.5</td>
<td>82.1</td>
<td>81.6</td>
<td>80.9</td>
<td>80.0</td>
</tr>
<tr>
<td>$ GDP/capita</td>
<td>35880</td>
<td>39730</td>
<td>41240</td>
<td>44870</td>
<td>48440</td>
</tr>
<tr>
<td>Gross Domestic Product (bil 2012$)</td>
<td>2960</td>
<td>3262</td>
<td>3365</td>
<td>3630</td>
<td>3875</td>
</tr>
<tr>
<td>m3 hydrogen/capita</td>
<td>125</td>
<td>135</td>
<td>132</td>
<td>138</td>
<td>144</td>
</tr>
<tr>
<td>m3 hydrogen/000$ GDP</td>
<td>3.5</td>
<td>3.4</td>
<td>3.2</td>
<td>3.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Refined Petro Prdts Prdn (mil m ton)</td>
<td>115.7</td>
<td>112.7</td>
<td>94.7</td>
<td>87.2</td>
<td>83.7</td>
</tr>
<tr>
<td>Chemical MVA (bil 2012$)</td>
<td>62.3</td>
<td>78.8</td>
<td>80.2</td>
<td>84.5</td>
<td>89.9</td>
</tr>
<tr>
<td>Manufacturing Value Added (bil 2012$)</td>
<td>613</td>
<td>726</td>
<td>750</td>
<td>806</td>
<td>865</td>
</tr>
<tr>
<td>Hydrogen Demand (bil m$)</td>
<td>10.3</td>
<td>11.1</td>
<td>10.8</td>
<td>11.2</td>
<td>11.5</td>
</tr>
<tr>
<td>Captive</td>
<td>7.7</td>
<td>8.8</td>
<td>8.5</td>
<td>8.5</td>
<td>8.4</td>
</tr>
<tr>
<td>Merchant</td>
<td>2.6</td>
<td>2.3</td>
<td>2.3</td>
<td>2.7</td>
<td>3.1</td>
</tr>
<tr>
<td>% Germany</td>
<td>22.9</td>
<td>21.2</td>
<td>21.0</td>
<td>21.4</td>
<td>21.3</td>
</tr>
<tr>
<td>W Europe Hydrogen Demand (bil m$)</td>
<td>44.9</td>
<td>52.4</td>
<td>51.4</td>
<td>52.3</td>
<td>54.0</td>
</tr>
</tbody>
</table>

**Sample Chart**

**WORLD MERCHANT HYDROGEN MARKET SHARE**

(70.5 billion cubic meters, 2013)

- Linde: 20.3%
- Praxair: 21.0%
- Air Liquide: 22.0%
- Air Products: 26.7%
- Others: 10.0%

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

Sales: $1.4 billion (2013, as reported by company)
Geographic Sales: (2013, as percent of total) Western Europe 32%, Eastern and Central Europe 35%, Asia 31%, and Other 2%
Employment: 5,400 (2013, as reported by company)
Key Products: hydrogen for plasma arc cutting, glass polishing, thermal spraying, food, and carburization applications, among others

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.

The Company is active in the world hydrogen industry through the manufacture of hydrogen and various other gases for plasma arc cutting, glass polishing, thermal spraying, food, and carburization applications, among others. Messer Group’s plasma arc cutting hydrogen gas is intended to provide clean cut surfaces, reduce metal waste and distortion, and enhance cutting speed, while glass polishing hydrogen is serves as fuel for a hydrogen/oxygen flame capable of melting and smoothing glass surfaces. Thermal spraying, which is used to protect such base metals as steel from corrosion, wear, and heat damage, is a process most frequently used in the automotive, aviation, mechanical engineering, mining, and trade industries. The Company’s hydrogen for food end uses includes GOURMET H Hydrogen E 949 gas, among others, while carburization hydrogen encompasses HYDROCARB gas

**TABLE VII-4**

<table>
<thead>
<tr>
<th>Item</th>
<th>2003</th>
<th>2008</th>
<th>2013</th>
<th>2018</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Domestic Product (bil 2012$)</td>
<td>5028</td>
<td>8692</td>
<td>13290</td>
<td>18810</td>
<td>25560</td>
</tr>
<tr>
<td>m³ hydrogen/000$ GDP</td>
<td>($/000 m³)</td>
<td>($/000 m³)</td>
<td>($/000 m³)</td>
<td>($/000 m³)</td>
<td>($/000 m³)</td>
</tr>
<tr>
<td>Hydrogen Demand</td>
<td>8.00</td>
<td>17.10</td>
<td>35.80</td>
<td>55.20</td>
<td>79.70</td>
</tr>
<tr>
<td>Petroleum Refining:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrocracking</td>
<td>3.88</td>
<td>8.65</td>
<td>21.15</td>
<td>34.15</td>
<td>49.90</td>
</tr>
<tr>
<td>Hydrotreating</td>
<td>2.91</td>
<td>6.55</td>
<td>16.30</td>
<td>23.80</td>
<td>32.30</td>
</tr>
<tr>
<td>Other Applications</td>
<td>0.89</td>
<td>1.97</td>
<td>4.60</td>
<td>9.90</td>
<td>17.00</td>
</tr>
<tr>
<td>Chemical Manufacturing</td>
<td>2.20</td>
<td>4.30</td>
<td>7.80</td>
<td>11.75</td>
<td>16.90</td>
</tr>
<tr>
<td>Other</td>
<td>1.92</td>
<td>4.15</td>
<td>6.85</td>
<td>9.30</td>
<td>12.90</td>
</tr>
</tbody>
</table>

**World Hydrogen** is a Freedonia study which offers historical data (2003, 2008, 2013) plus forecasts for 2018 and 2023 for demand by product and market by region and for 19 countries. The study also analyzes key market environment factors, details company market share and profiles top participants in the world hydrogen industry.
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World Catalysts

World demand for catalysts will grow at 4.8 percent per year to $20.6 billion in 2018. Growth will be led by a rebound in the chemical and polymer industries, most notably in developed economies hit hard by the recession. The fastest advances, however, will occur in developing areas such as the Asia/Pacific and Africa/Mideast regions. This study analyzes the $16.3 billion world catalyst industry, with forecasts for 2018 and 2023 by material, type, market, world region, and for 18 countries. The study also evaluates company market share and profiles industry players.

#3177 ............... December 2014 ............... $6500

Synthetic Lubricants & Functional Fluids

US synthetic lubricant and functional fluid demand will rise at 6.3 percent yearly to $6.3 billion in 2018. Engine oils will account for the largest share of gains, while Group II base oils will remain the fastest-growing type. The energy and power generation, automotive, and industrial machinery markets will grow the fastest. This study analyzes the $4.6 billion US synthetic lubricant and functional fluid industry, with forecasts for 2018 and 2023 by product, material and market. The study also evaluates company market share and profiles industry competitors.

#3176 ............... August 2014 ............... $5200

World Biofuels

World demand for biofuels is expected to expand at a 3.6 percent annual pace, reaching 115 million metric tons in 2018. North America and Central and South America will remain the largest regional markets, while the Asia/Pacific region grows the strongest from a relatively small base. Bioethanol will remain the leading biofuel. This study analyzes the 96.3 million metric ton global biofuel industry, with forecasts for 2018 and 2023 by product, world region, and for 22 countries. The study also evaluates company market share and profiles industry participants.

#3179 ............... August 2014 ............... $6200

World Activated Carbon

World demand for activated carbon is projected to rise at 8.1 percent per year to 2.1 million metric tons in 2018, driven by tightening pollution regulations and rising manufacturing activity. North America will remain the largest activated carbon market, while the Asia/Pacific region will slightly outpace and overtake North America by 2023. This study analyzes the global activated carbon industry, with forecasts for 2018 and 2023 by type, application, world region, and for 18 countries. The study also evaluates company market share and profiles industry participants.

#3172 ............... May 2014 ............... $6400

Lubricants

US lubricant demand will rise less than one percent annually to 2.5 billion gallons in 2018, valued at $27.5 billion. Although growth will be modest, this will be a reversal of an outright drop in demand between 2008 and 2013. Improved efficiency and less frequent oil replacement will be a common trend throughout light vehicle and other lubricant markets. This study analyzes the 2.4 billion gallon US lubricant industry, with forecasts for 2018 and 2023 by basestock, product and market. The study also evaluates company market share and profiles industry competitors.

#3143 ............... March 2014 ............... $5200