Ammonia Transportation, Distribution & Logistics

Argonne National Laboratory

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Agenda

- World Supply > Growth > Trade Flows
- Economic Issues Trade Ammonia
- North American Industry
- North American Transportation, Distribution, and Logistics
- What is NH3?
- How is NH3 transported & stored? By mode
Ammonia World Capacity Key Producing Areas

- China
- Russia Ukraine
- EEC
- USA
- Canada
- Middle East
- Indonesia
- Trinidad
World Capacity

Ammonia Capacity 000's mt N

- 30
- 15
- 7.5

2005

China

United States
Canada
Trinidad
Venezuela
Brazil
Argentina

Russia
Ukraine
Kazakhstan
Uzbekistan
India
Pakistan
Qatar
Egypt

Royster Clark
Forecast World Growth

- Production Dependent Upon Gas Costs
  - Middle East, Indonesia, Trinidad

- Developing Economies
  - China, Russia, India
World Growth

Ammonia Growth '000s mt

- 50
- 25
- 12.5

- 2005
- 2006
- 2007
Trade Flow Issues

- Supply: lower gas production costs
- Demand: agriculture, industrial
- Gas price regional
- Storage terminals compressed gas
- Hazardous material
- Expensive to handle
World Trade Flows
Estimated Ammonia Costs
Delivered to Mississippi River

USA $370

Trinidad $335

$25 Deliver

Russia $300

Ukraine $310

$65 Deliver

$70 Deliver
USA Ag Ammonia Supply - Demand

The chart illustrates the supply and demand of ammonia in the USA from 1995 to 2002. The categories include production, imports, exports, stocks, and demand. Each year is represented by different colors to indicate the volume of supply and demand. The production and demand figures are significantly higher than imports, exports, and stocks.
USA Ammonia Supply - Demand
# US Ammonia Imports

(million’s of tons of ammonia)

<table>
<thead>
<tr>
<th>Source</th>
<th>2002/03</th>
<th>2003/04</th>
<th>2003/04 Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinidad</td>
<td>3.8</td>
<td>4.2</td>
<td>53%</td>
</tr>
<tr>
<td>FSU</td>
<td>1.7</td>
<td>1.7</td>
<td>21%</td>
</tr>
<tr>
<td>Canada</td>
<td>1.3</td>
<td>1.3</td>
<td>17%</td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.3</td>
<td>0.3</td>
<td>4%</td>
</tr>
<tr>
<td>Middle East</td>
<td>0.1</td>
<td>0.1</td>
<td>1%</td>
</tr>
<tr>
<td>Others</td>
<td>0.1</td>
<td>0.3</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.3</strong></td>
<td><strong>7.9</strong></td>
<td><strong>100%</strong></td>
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</table>
Ammonia Imports by Region

Imports FY 03-04
7.9 Million tons

New Orleans
Texas
TAMPA
NA Base Capacity
NA Capacity Shutdown

- NG prices above $5 - 10
- 1.7 million N tons of 16.99 million capacity has closed
- Currently plants closed
  - Put names here
  - Total Capacity
  - Increased Imports Pipeline NOLA
NA Demand to Production

[Map showing demand to production across the United States with various color codes for different demand levels.]
USA Demand - 20.1 million tons

- Agriculture: 17.9 million tons
- Industrial: 2.2 million tons
Agriculture County Demand

Ammonia Demand 2002 by County

Tons

- 100 to 5,070
- 5,070 to 10,000
- 10,000 to 15,000
- 15,000 to 20,000
- 20,000 to 24,000
- 24,000 to 29,955
- Other
## State Production Capacity

<table>
<thead>
<tr>
<th>State</th>
<th>Capacity Tons</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>4,514,000</td>
<td>1</td>
</tr>
<tr>
<td>OK</td>
<td>2,515,000</td>
<td>2</td>
</tr>
<tr>
<td>AK</td>
<td>1,416,000</td>
<td>3</td>
</tr>
<tr>
<td>IA</td>
<td>791,000</td>
<td>4</td>
</tr>
<tr>
<td>GA</td>
<td>758,000</td>
<td>5</td>
</tr>
<tr>
<td>KS</td>
<td>695,000</td>
<td>6</td>
</tr>
<tr>
<td>TX</td>
<td>680,000</td>
<td>7</td>
</tr>
<tr>
<td>MS</td>
<td>669,000</td>
<td>8</td>
</tr>
<tr>
<td>OH</td>
<td>598,000</td>
<td>9</td>
</tr>
<tr>
<td>VA</td>
<td>584,000</td>
<td>10</td>
</tr>
<tr>
<td>TN</td>
<td>409,000</td>
<td>11</td>
</tr>
<tr>
<td>ND</td>
<td>400,000</td>
<td>12</td>
</tr>
<tr>
<td>IL</td>
<td>306,000</td>
<td>13</td>
</tr>
<tr>
<td>NE</td>
<td>292,000</td>
<td>14</td>
</tr>
<tr>
<td>AL</td>
<td>193,000</td>
<td>15</td>
</tr>
<tr>
<td>WY</td>
<td>192,000</td>
<td>16</td>
</tr>
<tr>
<td>OR</td>
<td>111,000</td>
<td>17</td>
</tr>
<tr>
<td>FL</td>
<td>86,000</td>
<td>18</td>
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### Ammonia Production Capacity by State
Plant Closures Gas to NOLA
Ammonia Price

Ammonia Gas Plants
Shutdown Assessments
Ammonia Plants and Terminals
Distribution

Ammonia Plants with US Rivers
Distribution

Ammonia Plants and US Railways
Distribution

Ammonia Pipelines to Plants
Williams
Kaneb
Tampa Bay Pipeline
Distribution

Total Ammonia Terminals
Distribution

Terminals to Ammonia Pipelines
Supply Chain Logistics

Production to Demand
- Vessel to Terminal
- Pipeline to Terminal
- Barge to Terminal
- Rail to Terminal
- Truck from Production

Truck delivery common mode end delivery agriculture
Anhydrous ammonia (\(NH_3\)) exists naturally in a gaseous state under atmospheric pressure and temperature. Under moderate pressure it changes easily to a liquid, becoming a gas again when the pressure is reduced. Industries take advantage of this characteristic by shipping and storing liquefied ammonia in pressurized railway cars, tank trucks and cylinders of various sizes.
SUPPLY-production

Ocean going vessel to terminal

Barge to terminal

Rail to terminal

Pipeline to terminal
Storage tanks

- NH₃ is stored in a liquefied state at approximately -28° F
- This is accomplished with refrigeration compressors
- NH₃ is loaded into trucks or rail cars using a heater
production to ocean going vessel

ocean going vessel to deep water terminal
Ship

- NH3 is liquefied by being cooled to approximately -28° F
- Ships keep cargo cool via refrigeration compressors
- Ships are also in LPG trade
deep water terminal or production to barge

barge to river terminal
Barge

- NH3 is liquefied and transported at approx. -28° F
- Barges use refrigeration compressors to cool cargo
- Typical NH3 tow is 5,000 st
- Age of barge fleet in US averages 40 years
- Cost of replacement approximately $5mm per barge
deep water terminal or production to rail

rail to inland terminal or end user
Rail

- NH₃ is shipped in a liquefied state under pressure, not refrigeration.
- NH₃ is actually heated from -28°F to between 30°F & 40°F for loading dependent upon outside temperature.
- Cars are insulated and pressurized.
deep water terminal or production to pipeline

pipeline to inland terminal
Pipeline

- NH3 is injected into the pipeline in a liquefied state under pressure, not refrigeration.
- NH3 is actually heated from -28° F to between 30° & 40° F for injection dependent upon pipeline temperature
- Pipeline is naturally insulated (underground)
- Pipeline is pressurized
terminal to truck
Trucks

- NH₃ is actually heated from -28° F to between 30° & 40° F for loading dependent upon outside temperature
- NH₃ is shipped in a liquefied state under pressure, not refrigeration.
IOWA
Closing Statements

- Ammonia and gas prices
- Further closing of NA plants
- Higher degree of imports
- Cost sensitive
- Current foot print of NH3 distribution
Questions????