Given an existing urea infrastructure for on-road vehicles, it is economically feasible to provide urea to Final Tier 4 nonroad diesel equipment

- Nonroad urea demand will be much lower than that for on-road vehicles and will not significantly impact a previously developed infrastructure.
- Delivery methods and packaging requirements identified for the on-road infrastructure are applicable to the nonroad market.
- Convenient distribution points will be added to deliver urea to a more fragmented market; convenience will come at a price since locations with higher urea throughput levels have a cost advantage.
- The largest impact of the nonroad urea demand would be the required increase of recyclable urea totes, barrels, and bottles.
- For both on-road and nonroad segments, approved intermediate storage containers will be required to ensure urea quality in the distribution chain.
- Urea selective catalytic reduction (SCR*) has an operational cost advantage over other emission control solutions.
- Implementation milestones for a nonroad urea infrastructure are an extension of previously identified on-road infrastructure milestones.

* Please see a full list of acronyms at the end of this report.
TIAx projected nonroad diesel consumption of 12.0 billion gallons in 2014 compared to 41.5 billion gallons for on-road vehicles.

- Using EPA’s models, TIAx projected the nonroad diesel consumption and distribution by market sector.
- The nonroad diesel consumption depends on the equipment population and does not take into account efficiency gains.
- In reality, efficiency gains are made in equipment powertrains and in work practices.
- Therefore, we use EPA’s modeled diesel consumption values to define our high diesel consumption case.

**2014 Nonroad Diesel Consumption**

<table>
<thead>
<tr>
<th>Market Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural</td>
<td>32.0%</td>
</tr>
<tr>
<td>Construction &amp; Mining</td>
<td>47.8%</td>
</tr>
<tr>
<td>Generators</td>
<td>4.1%</td>
</tr>
<tr>
<td>Commercial Equipment</td>
<td>1.2%</td>
</tr>
<tr>
<td>Forestry</td>
<td>2.1%</td>
</tr>
<tr>
<td>Industrial Machinery</td>
<td>10.0%</td>
</tr>
<tr>
<td>Recreational</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

12.0 billion gallons total

Sources: EPA Nonroad2005; Craig Harvey, EPA, ARB’s Offroad Model
Diesel consumed by Final Tier 4 equipment is a small portion of the annual consumption of the nonroad segment within the study period. Urea consumption is expected to be between 1 – 2 % of diesel consumption in these engines.
Overall nonroad urea consumption estimate is not large enough to significantly impact an existing on-road infrastructure during the study period.
The majority of nonroad urea volume is projected to come from on-road retail locations but average throughput will be low

- During the study period, large on-road retail locations could expect to increase throughput volume by 3% in 2014 and 8% in 2018
- Overall average throughput increase to on-road locations is much smaller due to the majority of the locations supplying a few additional gallons via bottles
- Nonroad urea demand divided among all non-road distribution points requires only 2 totes per month in 2018 in the highest throughput locations

<table>
<thead>
<tr>
<th>Nonroad Distribution Locations</th>
<th>Number of Locations</th>
<th>% of Urea Sales for Nonroad Sector</th>
<th>Average Monthly Urea Throughput from Nonroad Sector (gallons/location)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
<td>2018</td>
<td>2014</td>
</tr>
<tr>
<td>On-road Retail Locations</td>
<td>47,757</td>
<td>57,725</td>
<td>43.7%</td>
</tr>
<tr>
<td>Nonroad Diesel Wholesalers</td>
<td>6,800</td>
<td>8,000</td>
<td>40.9%</td>
</tr>
<tr>
<td>Nonroad Equipment Dealers</td>
<td>7,798</td>
<td>9,174</td>
<td>8.6%</td>
</tr>
<tr>
<td>Nonroad Equipment Repair Center</td>
<td>6,114</td>
<td>12,228</td>
<td>4.1%</td>
</tr>
<tr>
<td>Nonroad Fleet Locations</td>
<td>731</td>
<td>3,396</td>
<td>2.7%</td>
</tr>
</tbody>
</table>
Key distribution pathways and packaging identified in the on-road infrastructure study remain viable for nonroad applications

CDF Producing 32.5% Urea Solution For Mobile SCR

Pathway 1
Tanker Loads
- Facility receives tanker loads directly from CDF

Pathway 1a
Infrastructure
- Sales > 2500 gal/month
- Facility installs permanent UST/AST and dispensing system

Pathway 1b
Stillages
- Sales 500-7,500 gal/month
- Facility utilizes purchased, refillable dispensing systems

Pathway 2
Packages
- Distributor ships non-refillable, recyclable containers to retail site

Pathway 2a
Totes/barrels
- Sales < 500 gal/month
- Retail site uses totes that are dropped off full, replaced when empty

Pathway 2b
Bottles
- Sales < 50 gal/month
- Retail site uses bottles and/or sells bottles to customers

Source: EMA Study 2006
Distribution pathway and price are dependent on throughput volume at each distribution location

**Notes:*
1. Pathway 1a and 1b prices include a $0.32 markup split between the CDF and the retailer.
2. Pathway 1a assumes a 5500 gallon tank
3. Pathway 1b assumes a 1300 gallon stillage
4. Assumes 200 $/ton urea FOB

_Note:_ For direct comparison to on-road urea, prices are shown without mobile fueler delivery charge, which is expected to be between $0.50 & $1.00/gallon

_Source:_ EMA Study 2006
Points of convenience will be added to make urea available to the nonroad market, since bringing equipment to filling location is not always possible.

- Bulk petroleum wholesalers, central to the distribution of non-road diesel fuel, are most likely location for high urea throughput.
- Largest fleets with on-site fuel storage will store urea on-site because of their high consumption rates.
- Equipment dealers and repair centers will fill urea tanks on the equipment they contact and sell small quantities to new owners.
- Existing, on-road retail locations will more easily handle volume increases resulting from demand growth.
Price comparison of on-road retail locations and nonroad retail locations shows the price advantage of higher throughput locations

- On-road retail price range includes locations with tanks, stillages, totes/barrels, and bottles
- Non-road locations are expected to only employ totes/barrels and bottles in the 2014-2018 time period
- ‘Convenience locations’, or locations that carry urea to ensure distribution coverage without significant throughput, are expected to have similar delivery method and prices, whether they supply on-road or nonroad urea needs
- Weighted average price is based on the distribution method by volume

<table>
<thead>
<tr>
<th>Distributed Price ($/gallon)</th>
<th>On-road Retail Location</th>
<th>Nonroad Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>$1.10 - $7.50</td>
<td>$3.20 - $7.50</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>$2.34</td>
<td>$4.25</td>
</tr>
</tbody>
</table>
Largest impact to an existing infrastructure would be the required increase in the number of recyclable packages to support the nonroad urea market

- Approximately 70% increase in number of totes, barrels and bottles needed in 2018 for all mobile equipment
- Production volume increase will depend on recycle rates
- “Markets exist today to produce, deliver and recycle all of the proposed containers up to and including the IBC sizes”. – Barry Lonsdale, Terra Industries, 3/1/07
- The range of units corresponds to the low and high urea consumption forecasts

**On-road Urea Demand Only**

**Urea Demand for All Mobile Sources**

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Note: 264 gallon (1000L) tote was used as estimate based on European experience, other sizes may be applicable to NA market

Source: EMA Study 2006, Barry Lonsdale - Terra Industries
To ensure urea quality, refillable intermediate storage containers will need to be identified for the storage and transport of urea

- These containers will likely be prevalent in the distribution of urea to the nonroad market
- Intermediate storage containers are likely to be used to deliver small volumes to vehicles at high volume prices
- In all urea pathways other than the retail bottle, an intermediate container would likely be needed:
  - The large farmer with on-site storage will need to bring urea to the equipment from the tote or barrel stored at the garage
  - The jobber (independent or company owned) will need to store urea on the fuel truck in a container smaller than a 55 gallon drum
  - The smaller fleet owner will need to transport urea from the point of purchase to the equipment
- Container volume will depend on if or how often the container will be refilled by the operator at a lower priced retail location, i.e. tank or stillage
The urea-SCR solution is projected to have an operating price advantage over alternative technologies that have a fuel economy penalty

- Annual cost analysis uses average population and use factors by market sector
- Assumes capital, replacement, and maintenance costs to be roughly equivalent for urea-SCR and competing technologies
- The fuel economy difference is estimated to be 5%

<table>
<thead>
<tr>
<th></th>
<th>Agricultural Equipment</th>
<th>Construction and Mining</th>
<th>Industrial Machinery</th>
<th>Commercial Equipment</th>
<th>Forestry Equipment</th>
<th>Generators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea Consumption %</td>
<td>2% (High scenario consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Urea Cost $/gal</td>
<td>$2-34 - $4.25 (On-road retail average price vs. Nonroad average price)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected Urea Cost $/year/equipment</td>
<td>$100 - $180</td>
<td>$230 - $410</td>
<td>$160 - $280</td>
<td>$120 - $220</td>
<td>$500 - $900</td>
<td>$100 - $180</td>
</tr>
<tr>
<td>Alternative Technology Fuel Economy Difference %</td>
<td>5 % (TIAX estimate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Diesel Cost $/gal</td>
<td>$1.89 - $2.94 (EIA projected price in 2014 vs. Today’s price)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative Technology Cost $/year/equipment</td>
<td>$200 - $260</td>
<td>$460 - $600</td>
<td>$320 - $410</td>
<td>$240 - $320</td>
<td>$1000 - $1310</td>
<td>$190 - $260</td>
</tr>
</tbody>
</table>
Implementation milestones for an SCR-urea infrastructure are identified as an extension of on-road milestones

- **2006**: EMA and AAM make separate agreements with EPA on terms of SCR use
- **2007**: EPA releases SCR Draft Guidance Document
- **2008**: Introduction of LDD with SCR urea
- **2009**: Strong signals sent to downstream stakeholders about impending need for SCR urea infrastructure
- **2010**: Introduction of HDD with SCR urea
- **2010**: Engine manufacturers commit to SCR urea for nonroad engines
- **2011**: Construction lead-time activities begin at retail fueling stations
- **2011**: Manufacturing construction for totes, stillages and bottles
- **2011**: Retail vendors, distributors and urea manufacturers begin planning
- **2012**: Construction begins at distribution facilities
- **2012**: On-road retailers procure totes, barrels, bottles
- **2012**: Retailers procure stillages and permits
- **2013**: On-road SCR urea infrastructure fully implemented
- **2013**: Engine manufacturers commit to SCR urea for nonroad engines
- **2014**: Nonroad retailers procure totes, barrels, bottles
- **2014**: Nonroad SCR urea infrastructure fully implemented
- **2014**: Introduction of SCR urea on 75-174hp NR engines
- **2014**: Production increase commitments from tote, barrel and bottle manufacturers
- **2014**: Secure commitments from nonroad retail locations to provide urea in 2014
The following acronyms are used throughout the executive summary

- AAM – Alliance of Automotive Manufacturers
- ARB – California Air Resources Board
- CDF – Central Distribution Facility
- EMA – Engine Manufacturers Association
- EPA – US Environmental Protection Agency
- FOB – Free On Board, delivered price
- HDD – Heavy Duty Diesel
- HP -- Horsepower
- IBC – Intermediate Bulk Container
- LDD – Light Duty Diesel
- MMgal – Million gallons
- NR – Nonroad
- SCR – Selective Catalytic Reduction
- UST/AST – Underground/Above-ground Storage Tank