Nonroad SCR-Urea Study Executive Summary

Engine Manufacturers Association

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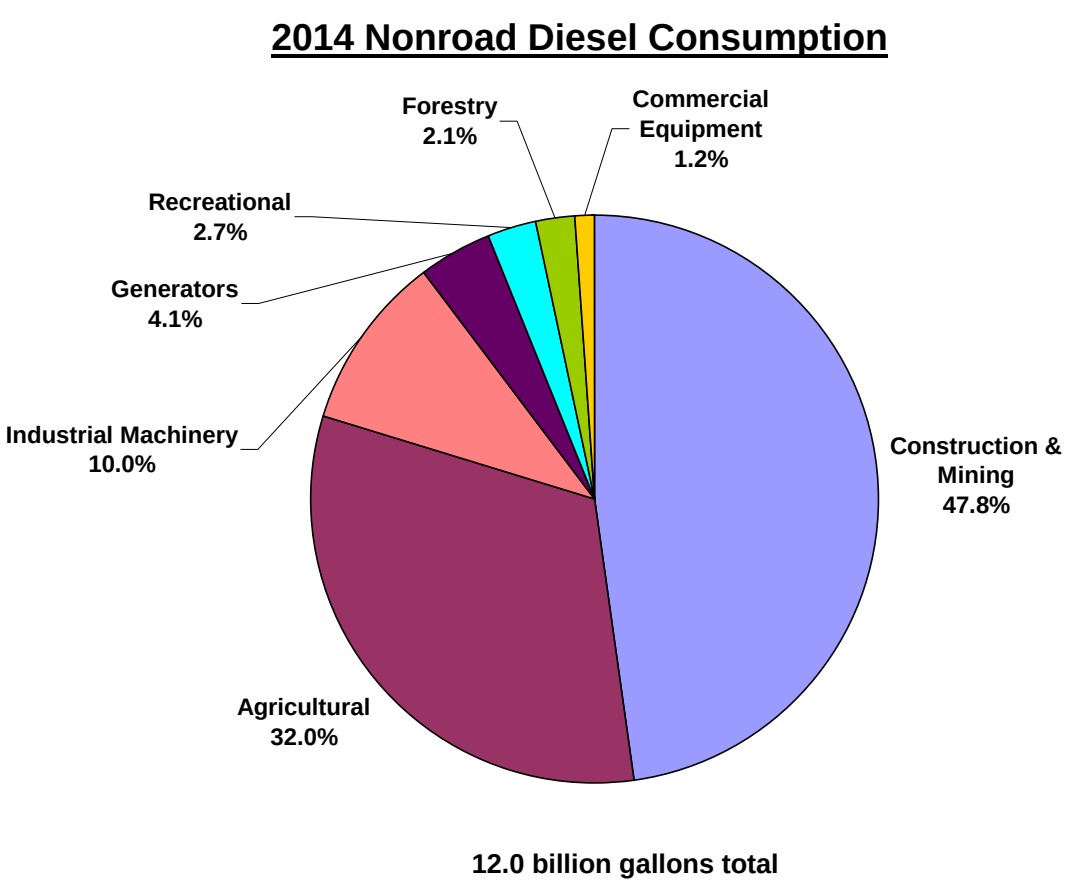
Reference:D.5535

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

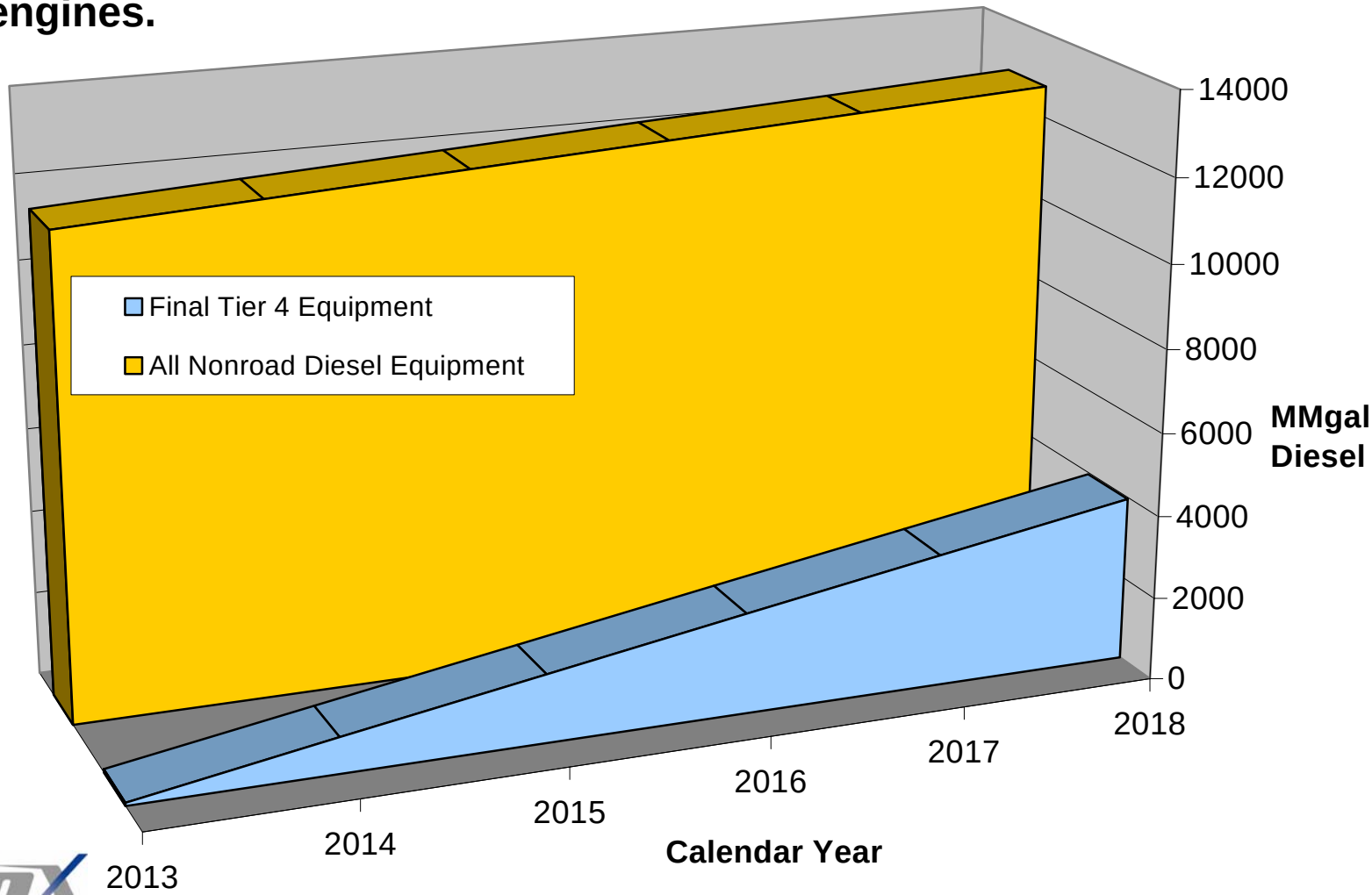
TIAX projected nonroad diesel consumption of 12.0 billion gallons in 2014 compared to 41.5 billion gallons for on-road vehicles



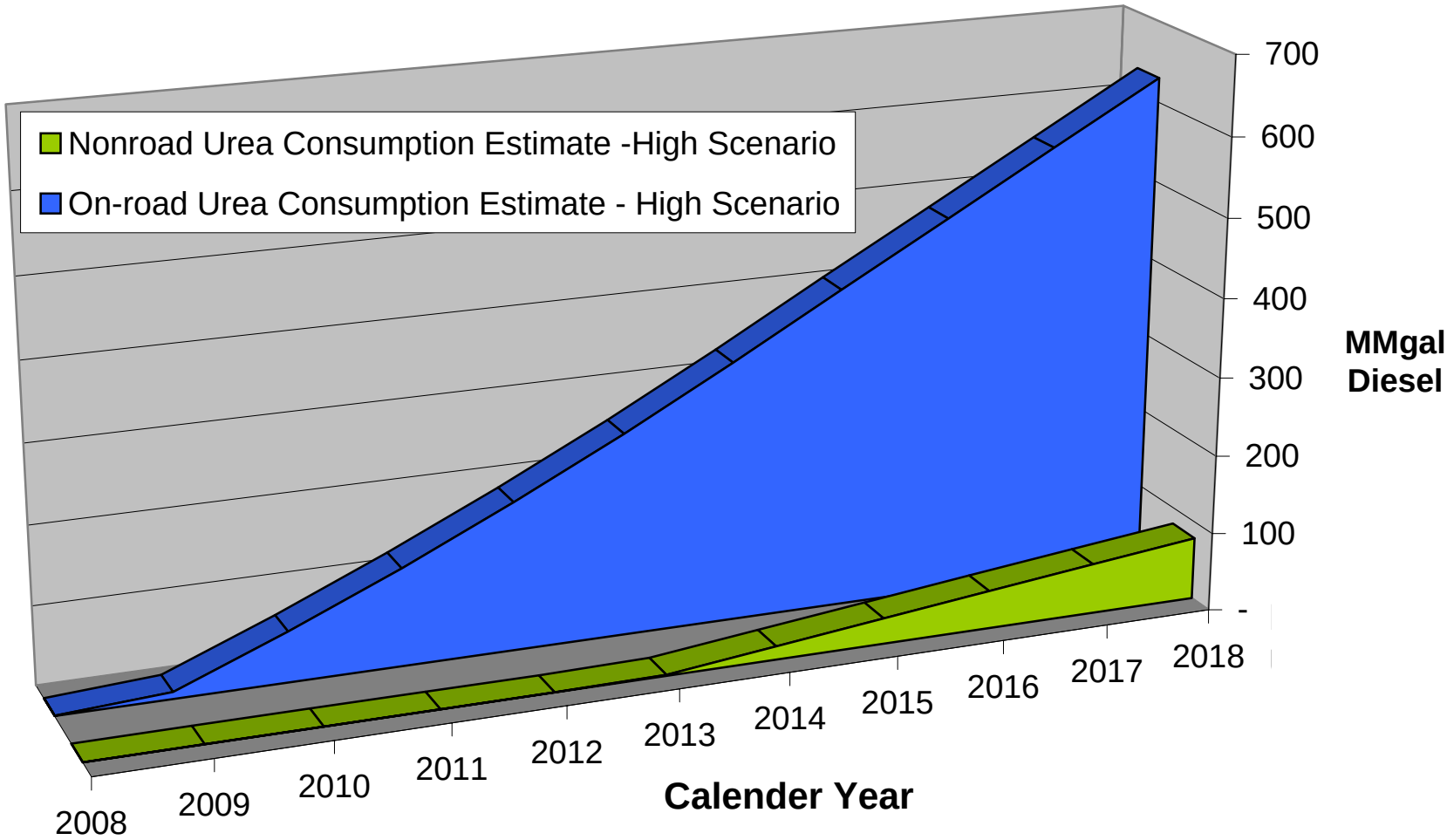
- Using EPA's models, TIAX projected the nonroad diesel consumption and distribution by market sector
- The nonroad diesel consumption depends on the equipment population and does not take into account efficiency gains
- In reality, efficiency gains are made in equipment powertrains and in work practices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

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

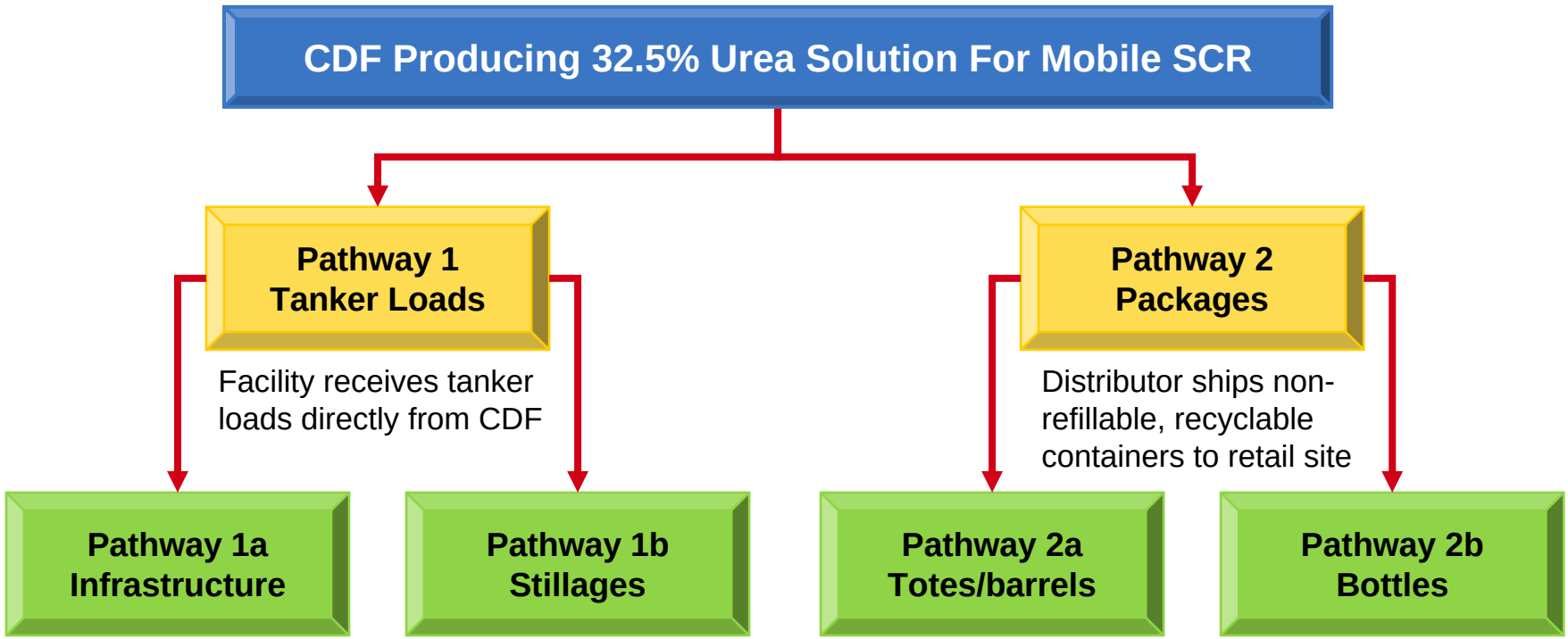


The majority of nonroad urea volume is projected to come from on-road retail locations but average throughput will be low

- 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

Nonroad Distribution Locations	Number of Locations		% of Urea Sales for Nonroad Sector		Average Monthly Urea Throughput from Nonroad Sector (gallons/location)	
	2014	2018	2014	2018	2014	2018
On-road Retail Locations	47,757	57,725	43.7%	41.9%	10	36
Nonroad Diesel Wholesalers	6,800	8,000	40.9%	39.4%	65	243
Nonroad Equipment Dealers	7,798	9,174	8.6%	4.3%	12	23
Nonroad Equipment Repair Center	6,114	12,228	4.1%	8.3%	7	33
Nonroad Fleet Locations	731	3,396	2.7%	6.2%	40	91

Key distribution pathways and packaging identified in the on-road infrastructure study remain viable for nonroad applications



- Sales > 2500 gal/month
- Facility installs permanent UST/AST and dispensing system

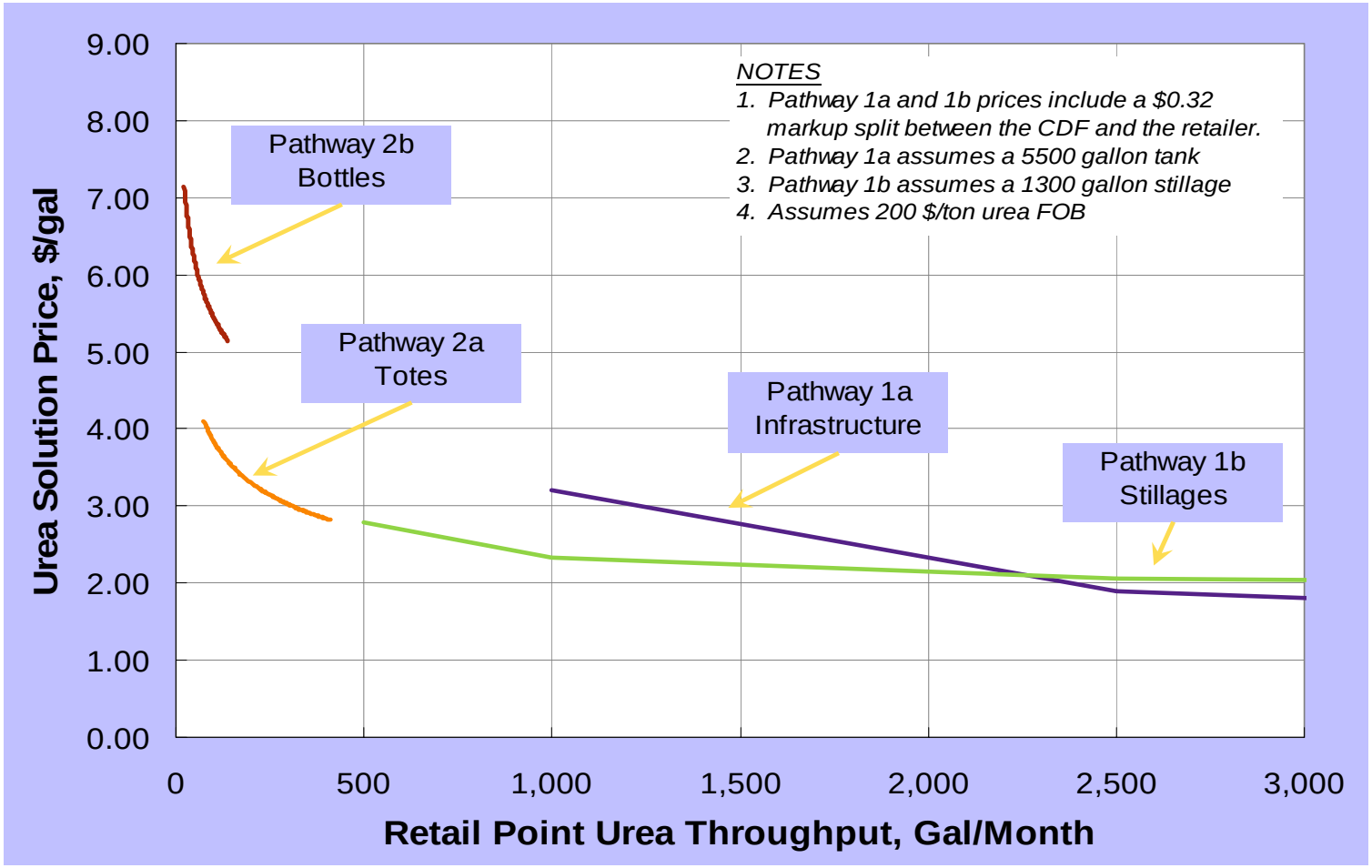
- Sales 500-7,500 gal/month
- Facility utilizes purchased, refillable dispensing systems

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

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

Source: EMA Study 2006

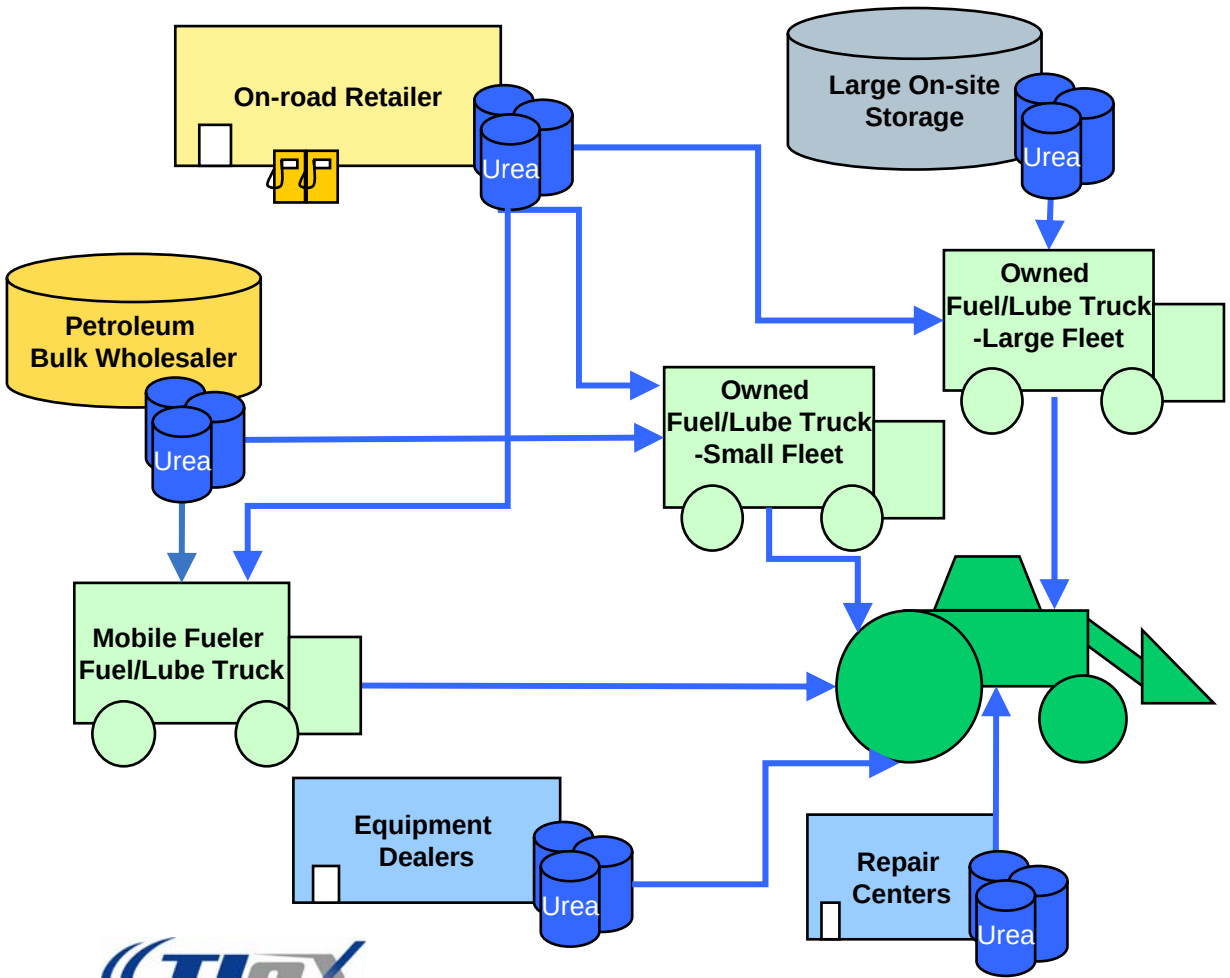
Distribution pathway and price are dependent on throughput volume at each distribution location



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

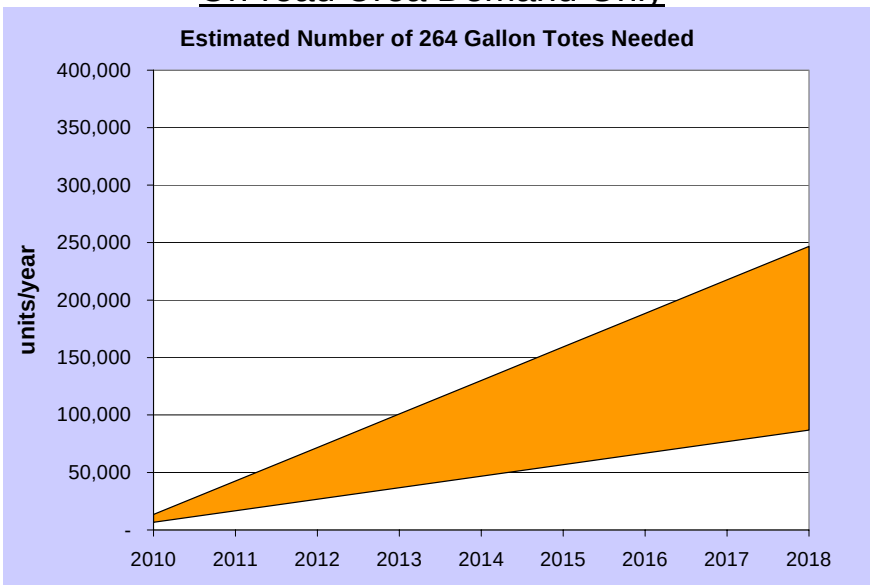
- On-road retail price range includes locations with tanks, stillages, totes/barrels, and bottles
- Non-road locations are expected to only employ totes/barrels and bottles in the 2014-2018 time period
- 'Convenience locations', or locations that carry urea to ensure distribution coverage without significant 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

	Distributed Price ($/gallon)	
	On-road Retail Location	Nonroad Location
Range	$1.10 - $7.50	$3.20 - $7.50
Weighted Average	$2.34	$4.25

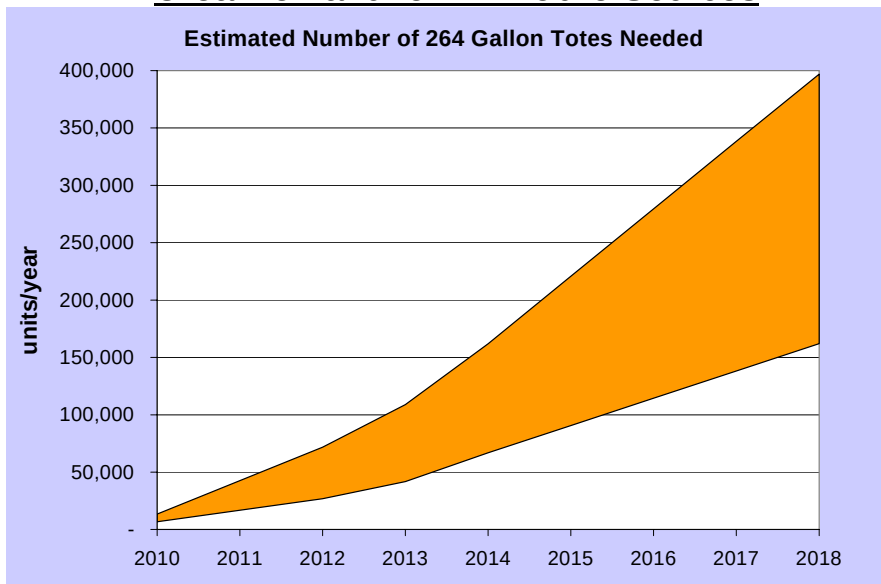
Largest impact to an existing infrastructure would be the required increase in the number of recyclable packages to support the nonroad urea market

- 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



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

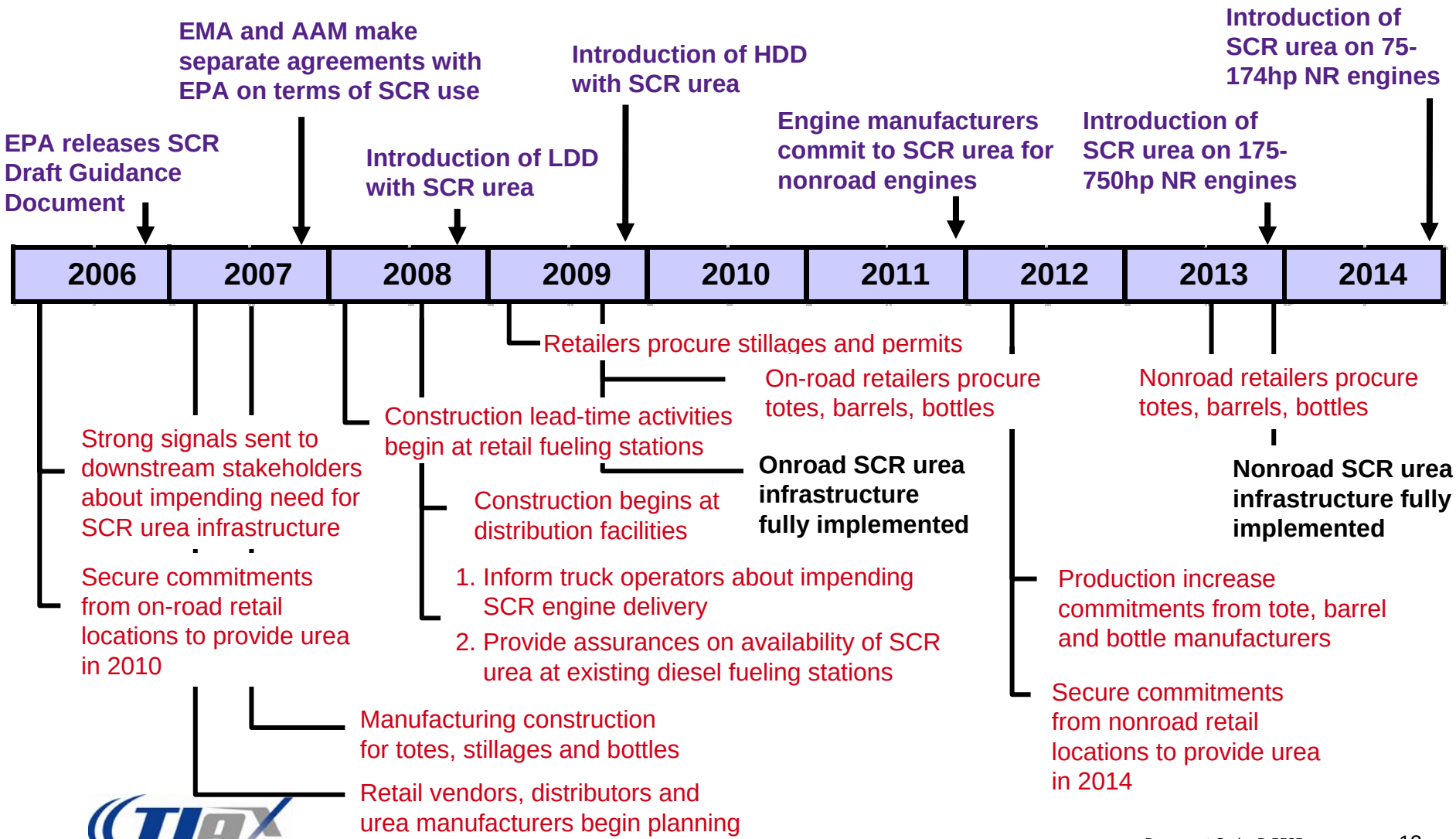
- These containers will likely be prevalent in the distribution of urea to the nonroad market
- Intermediate storage containers are likely to be used to deliver small volumes to vehicles at high volume prices
- In all urea pathways other than the retail bottle, an intermediate container would likely 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%

	Average Annual Cost Analysis					
	Agricutural Equipment	**Construction and Mining**	**Industrial Machinery**	**Commercial Equipment**	**Forestry Equipment**	**Generators**
Urea Consumption %	2% (High scenario consumption)					
Average Urea Cost $/gal	$2-34 - $4.25 (On-road retail average price vs. Nonroad average price)					
Projected Urea Cost $/year/equipment	$100 - $180	$230 - $410	$160 - $280	$120 - $220	$500 - $900	$100 - $180
Alternative Technology Fuel Economy Difference %	5 % (TIAX estimate)					
Ave. Diesel Cost $/gal	$1.89 - $2.94 (EIA projected price in 2014 vs. Today's price)					
Alternative Technology Cost $/year/equipment	$200 - $260	$460 - $600	$320 - $410	$240 - $320	$1000 - $1310	$190 - $260

Implementation milestones for an SCR-urea infrastructure are identified as an extension of on-road milestones



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