

SCR Challenges and Opportunities

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2007-2010 Emission Requirements

- The 2007 – 2010 emission requirements pose a significant technical challenge to the industry
- NOx and Particulate, the primary regulated constituents will be reduced by 90% compared to 2004 levels, upon complete implementation of the rule
- Initial costs and life cycle costs will be a challenge for the industry
- Environmental benefit can be optimized when the manufacturers provide engines / vehicles which provide users with a return on their investment

Solutions to the 2007 Challenge

- DDC is committed to provide solutions which focus on all of the 2007 and beyond objectives
 - Meeting the emission requirements
 - Providing the best value to the end user customer
 - Provide the best reliability, durability and service support

SCR Opportunity

- SCR technology has the potential to provide significant economic benefit to end users while also providing the regulated emission reduction
 - Improved fuel consumption
 - Increased oil drain intervals
 - Reduced engine heat rejection resulting in simplified vehicle cooling requirements
 - Reduced weight through smaller displacement engines as compared to other options
 - Comparable initial cost than other alternatives
 - Proven technology
 - Available for fleet testing

SCR Challenge

- SCR technology requires the use of a second fluid , urea, which serves as the reducing agent for the SCR catalyst
 - An infrastructure for the distribution of this product to heavy duty trucks is required
 - This infrastructure must parallel the fueling infrastructure for heavy duty trucks
 - End users must maintain the proper fluid and fluid level in the vehicles urea tank

Urea

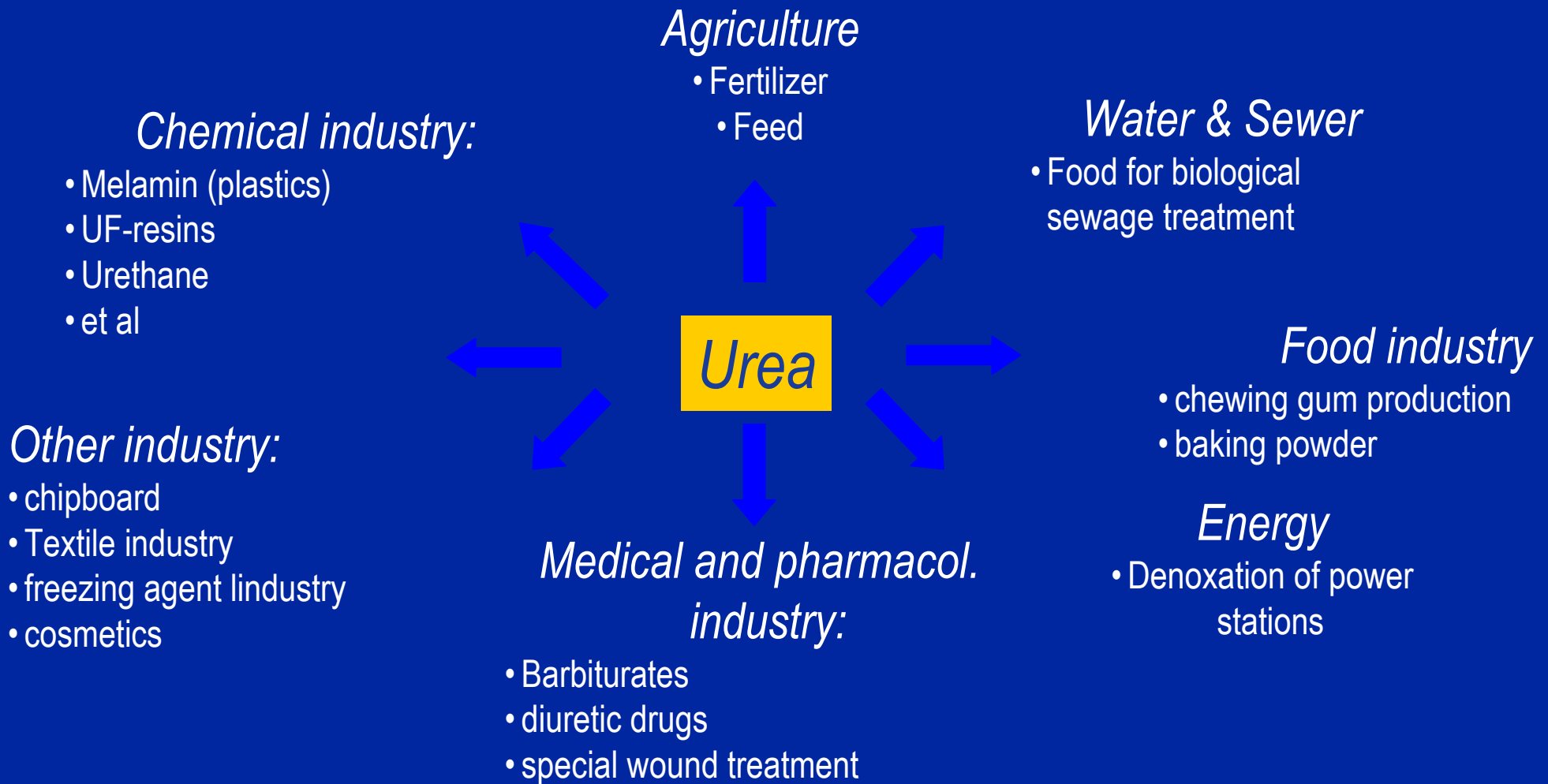
- Urea is a nitrogen compound with many commercial uses
 - Fertilizer
 - Production of adhesives and resins
 - Animal feed supplement
 - Cosmetics and pharmaceutical industry
- SCR systems use a high quality urea —currently available for use in SCR systems in the stationary power generation
- Chemical grade urea is diluted in demineralized water to a concentration level of 32.5%

Urea

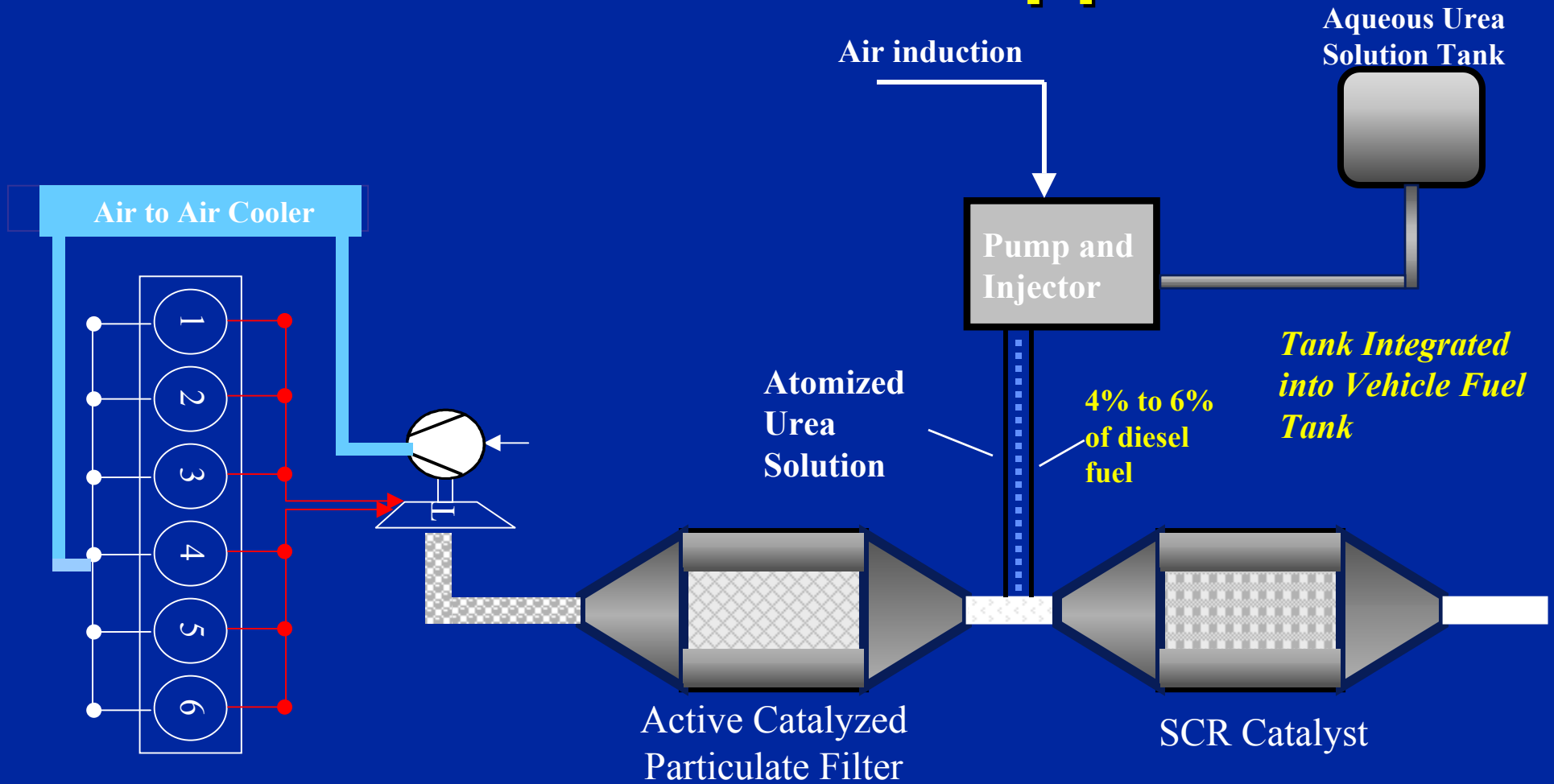
Chemical & physical specification:

- $\text{H}_2\text{N-CO-NH}_2 + \text{H}_2\text{O}$
- $32.5\% \pm 0.5\%$ concentration in water
 - Clear transparent, odorless
 - Acidity (pH-value) max. 10
 - Freezing point -11°C (12°F)
 - Crystallization point 133°C
 - Self ignition temperature 630°C
 - Non toxic

Urea

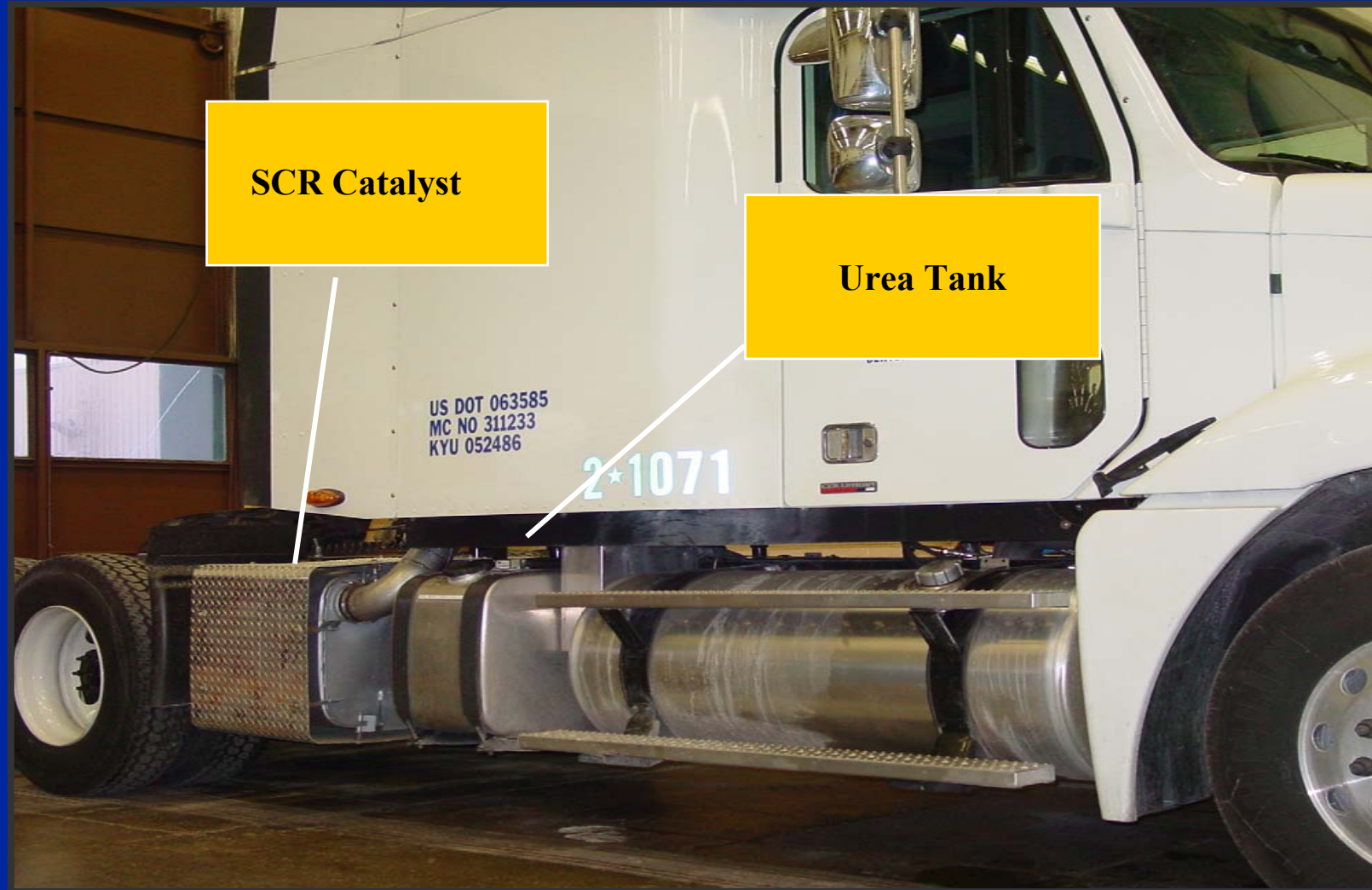


The SCR & Particulate Filter Approach

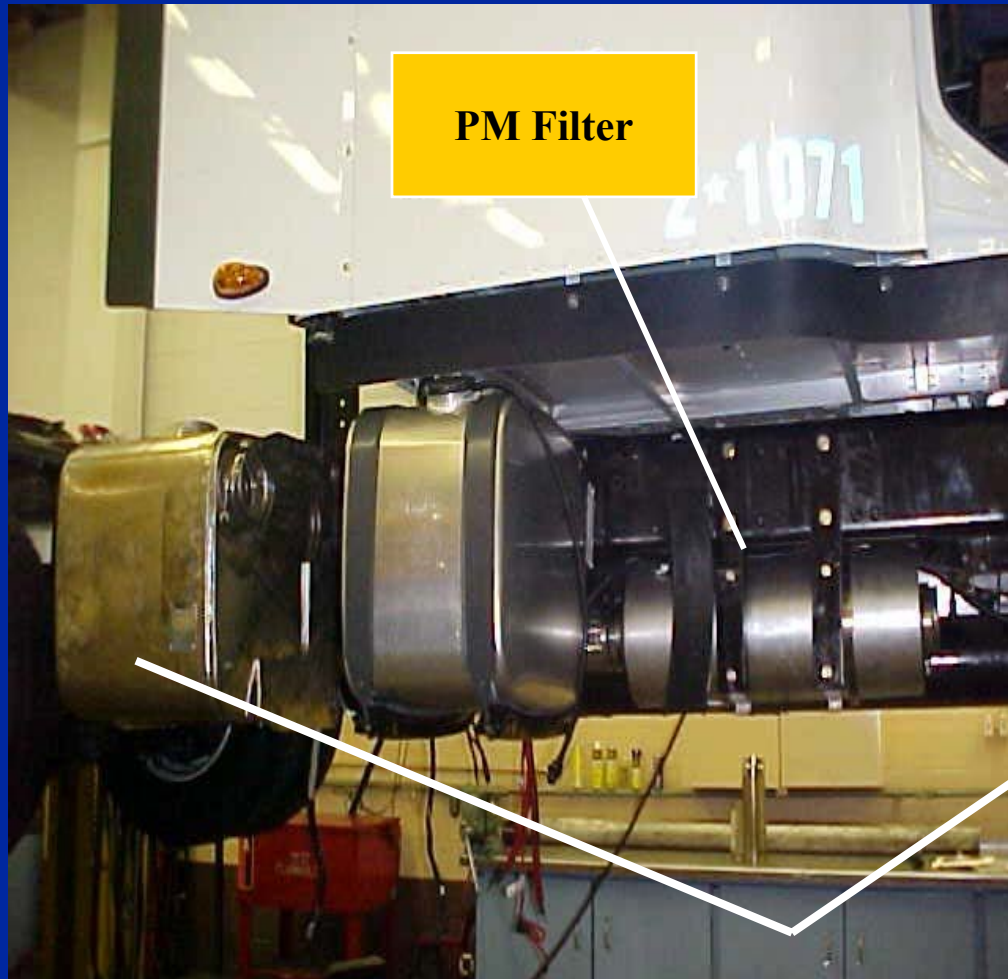


Both Catalysts Integrated into Vehicle Exhaust System

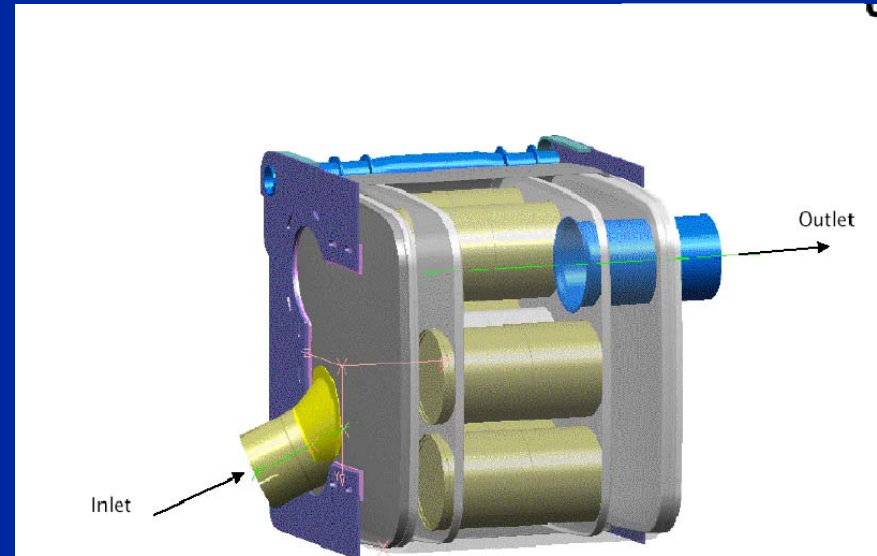
SCR / PM Filter Application



SCR / PM Filter Application



Cross Section of SCR Catalyst



SCR Application



Example of typical application

Diesel Fuel Tank 200 gallons

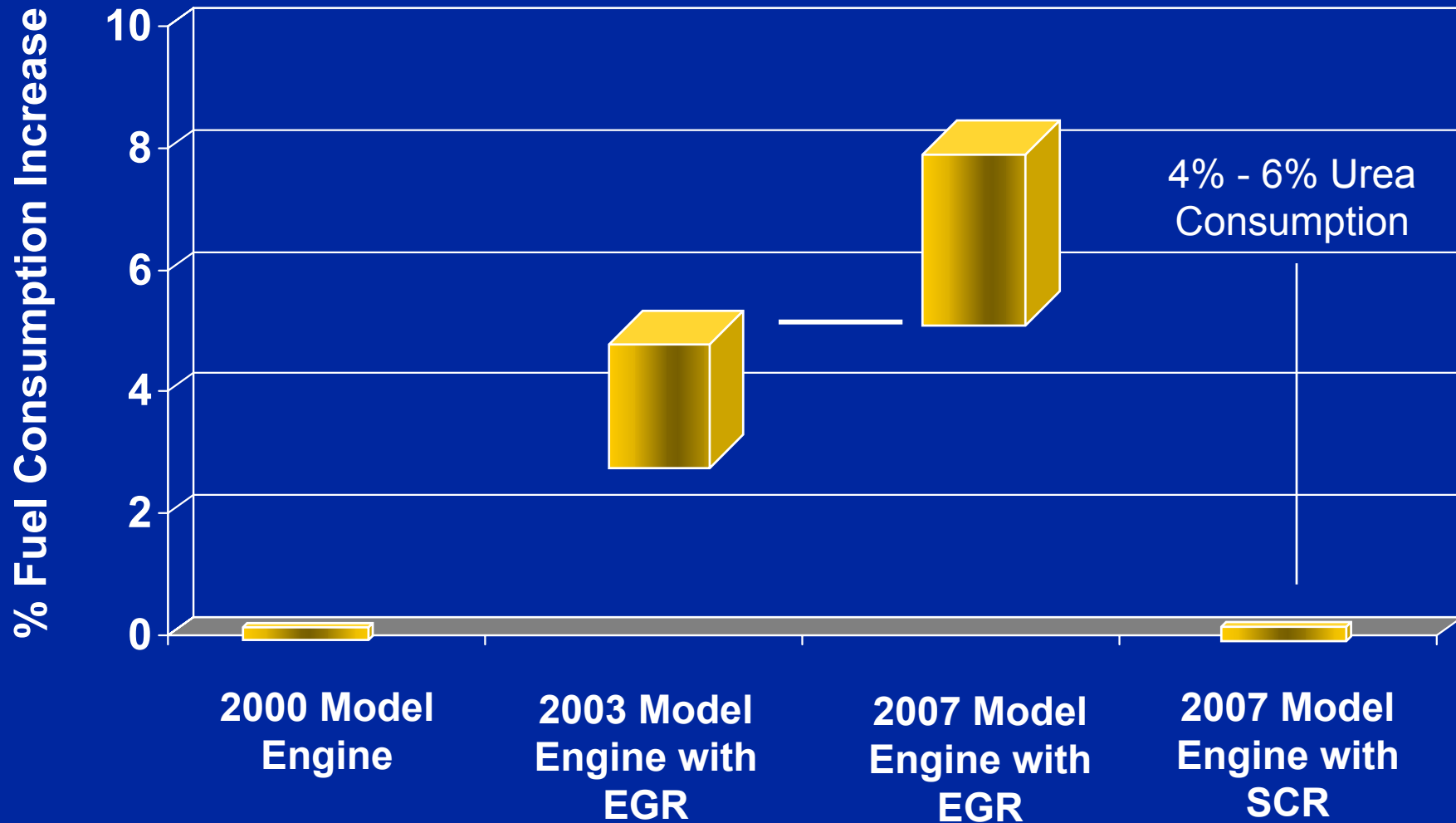
Urea Tank 30 gallons

Vehicle Range based on diesel fuel capacity = 1360 miles (6.8 mpg)

Vehicle Range based on urea capacity = 5100 miles

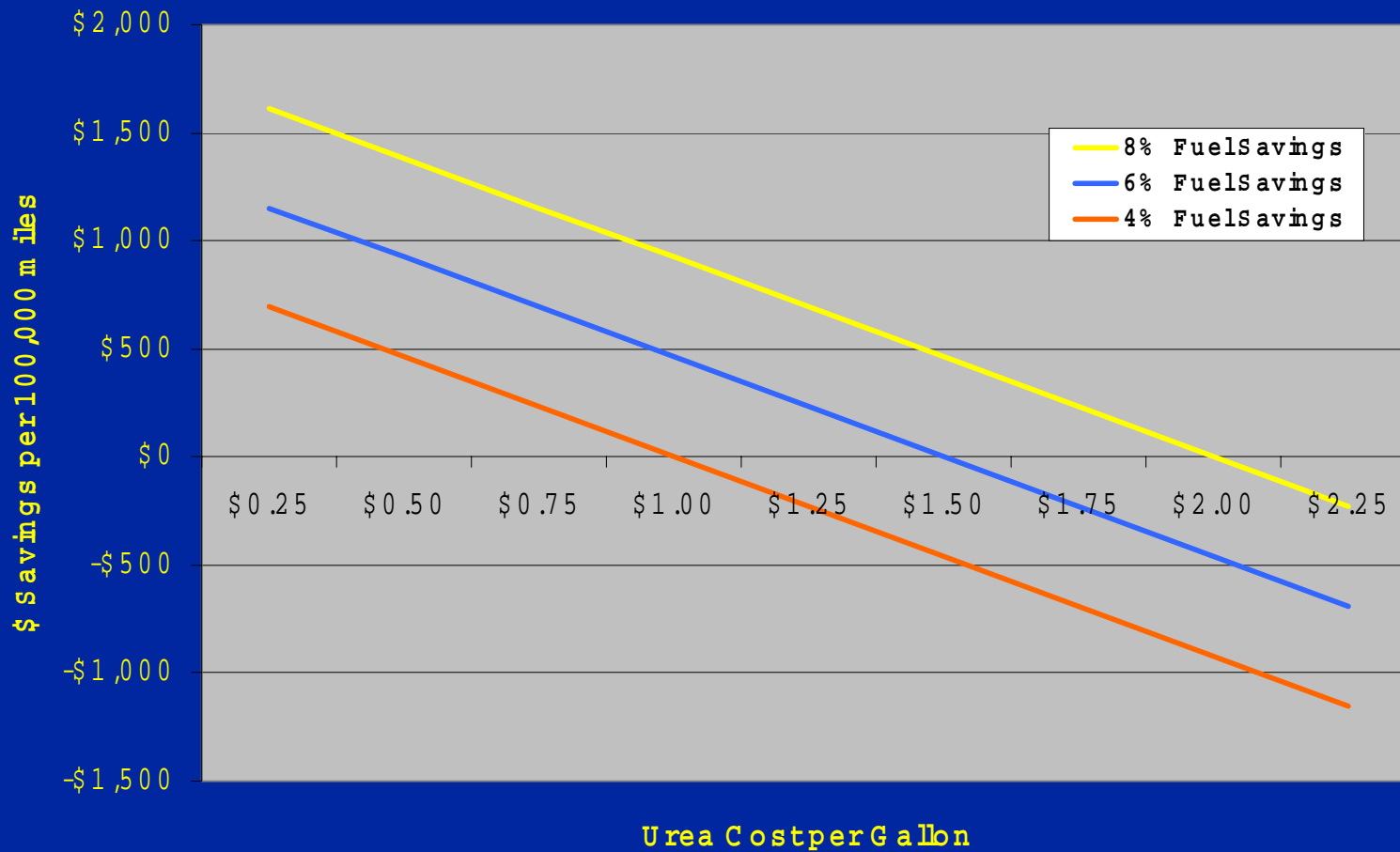
(4% consumption ratio)

SCR Opportunities



SCR Opportunity

Urea Cost Sensitivity as a Function of Fuel Savings Versus other Options
Assume 6% urea consumption



SCR Opportunities

2007 Oil Drain Intervals



Increased soot loading from EGR

Reduced ash content oils to optimize particulate filter maintenance

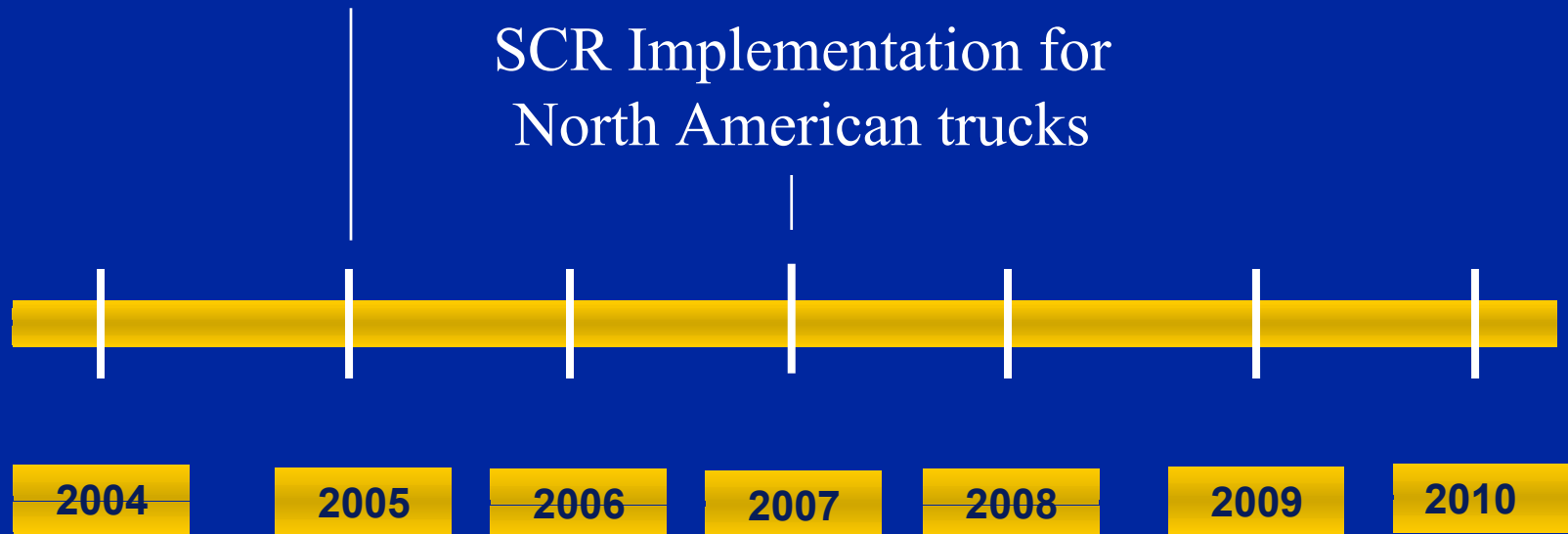
SCR Opportunities

- Reduced Heat Rejection
- Smaller vehicle radiators
- No impact on vehicle aerodynamics
- Reduced cooling fan operation and fan cycling
- Net benefit on fuel consumption

SCR Opportunities

SCR Implementation for
European trucks

SCR Implementation for
North American trucks



SCR demonstrations for
for North American
fleets

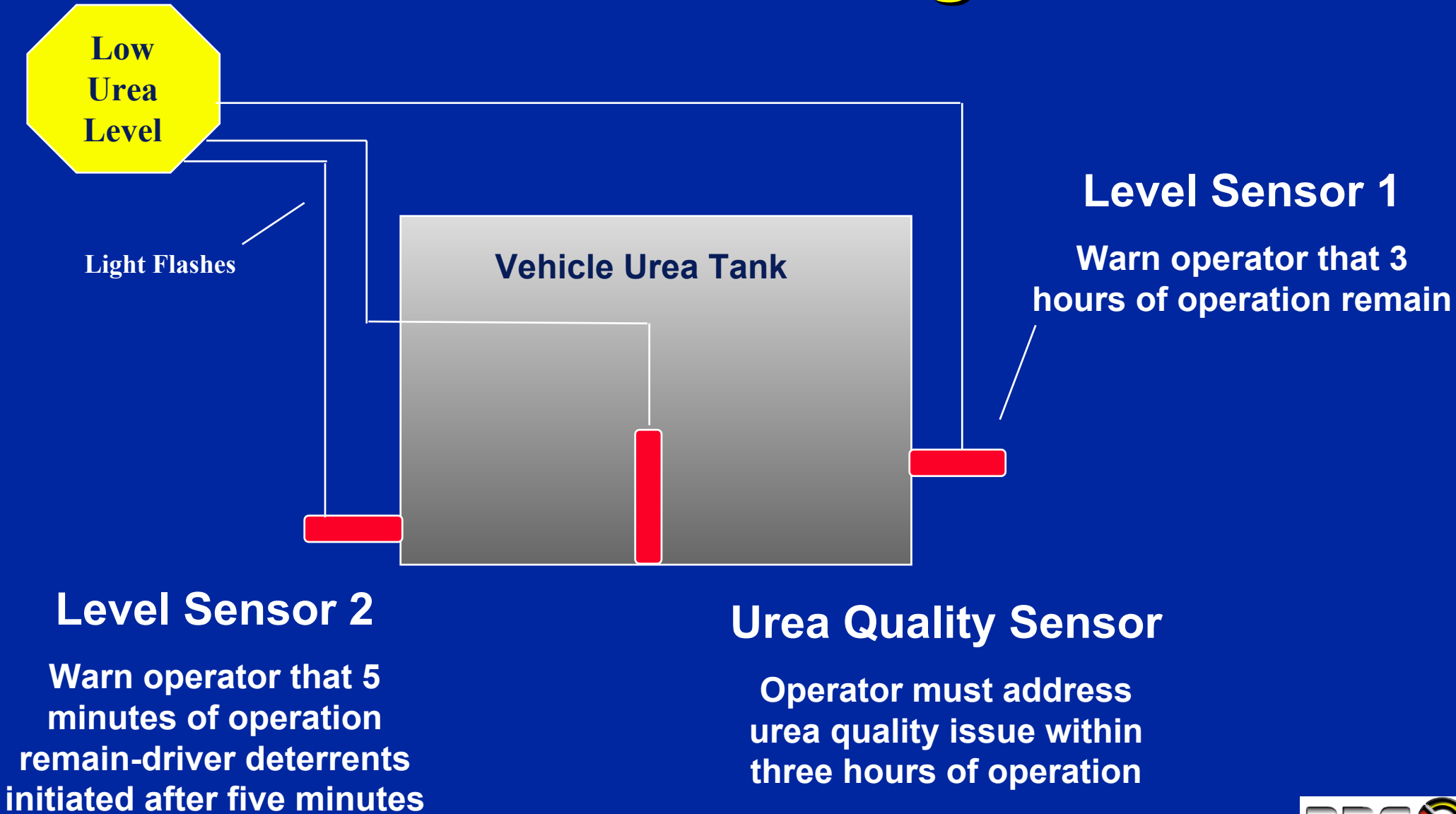
SCR Challenge

- The infrastructure must insure that sufficient urea is available at facilities where heavy duty trucks are fueled
- Urea when stored at these facilities must be kept from freezing (12°F)
- Urea cost must be such that economic benefit is provided to end users

SCR Challenge

- Proper urea level and concentration levels must be maintained during vehicle use
- Vehicle operators or maintenance staffs must fill the urea tank as they do with other fluids on the vehicle

SCR Challenge



SCR Challenges and Opportunities

■ Conclusion

- Technology decision must be made soon in order to meet the overall timeline
- SCR technology is proven and can achieve the 2007 emission levels
- SCR poses an attractive alternative which will provide the end user a benefit and incentive to purchase new lower emitting engines
- Urea infrastructure is needed to support this technology
- Sufficient lead time exists to establish this infrastructure