

Aaqius & Aaqius

VENTURE BUSINESS COMPANY
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Review of SCR technologies for Diesel Emission Control : European experience and Worldwide perspectives

AUGUST
2004

Author and speaker :
Joint Authors :

Dr. Emmanuel Joubert
Dr. Thierry Seguelong
Nicolas Weinstein



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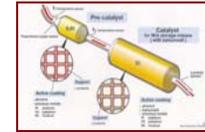
A Worldwide study on DeNOx market in EU & US

50 contacted companies / 100 leaded interviews

OEMs LDV & HDV		EMS / Catalyst / EGR / Cannerns		Urea Suppliers Petroleum Industrie		Legislations Bodies	
							
15 companies contacted		17 companies contacted		10 companies contacted		7 companies contacted	

***Aaqius & Aaqius led a large-scale study in Europe and US
to draw up a complete panorama of the DeNOx market
and identify the stakes & the value chain.***

Comparison of DeNOx Technologies



Exhaust Gas Recirculation (EGR)

- 😊 US target choice on HDV for US 07
- 😞 Not enough for US10

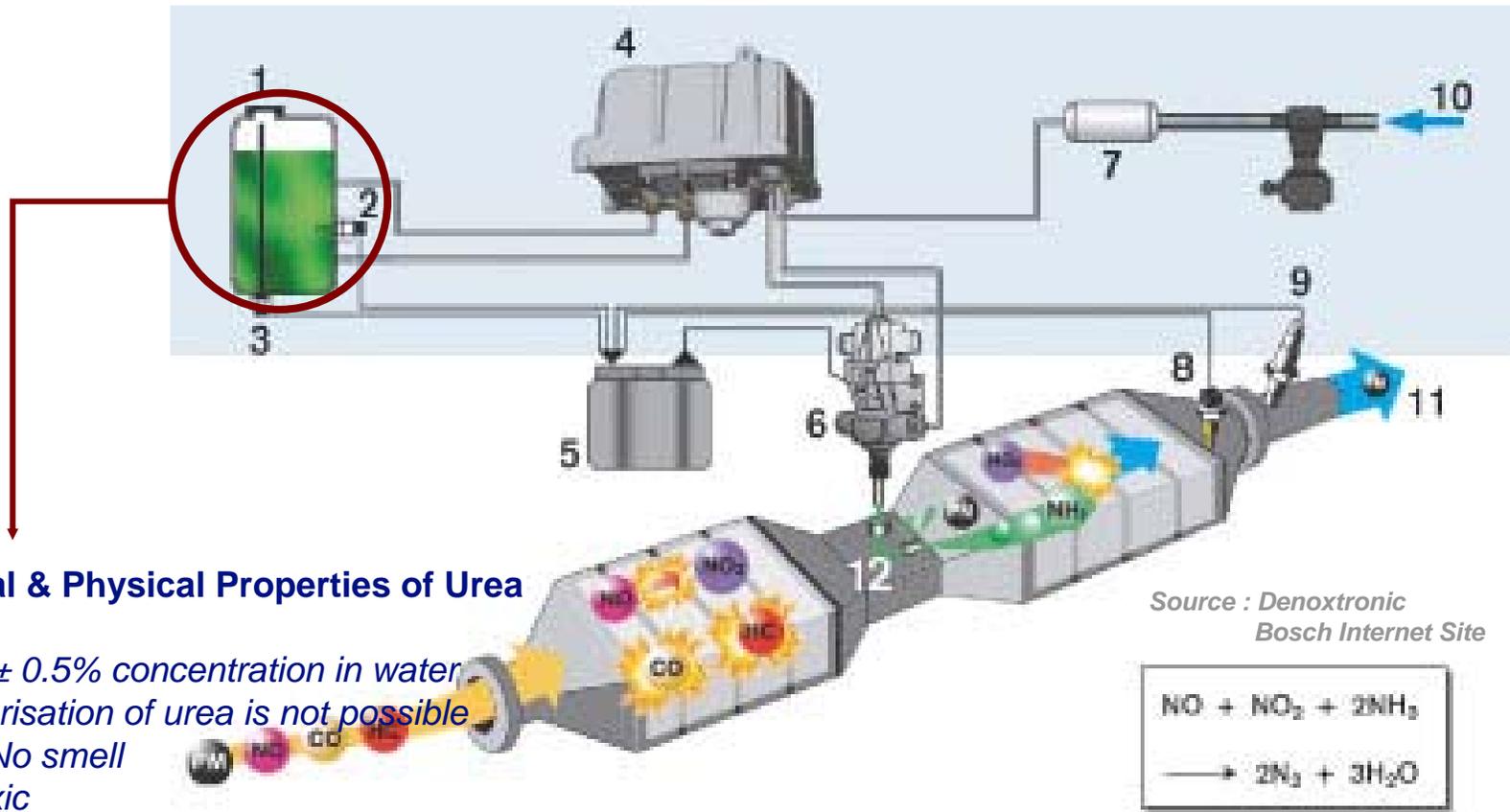
Lean NOx Trap (LNT)

- 😊 No extra fluid
- 😊 Passive to driver
- 😞 Weak durability
- 😞 Fuel penalty (lean/rich regimes 2 min/1s)
- 😞 Need advanced engine control (Lean /rich balance)
- 😞 PMG cost (Pt, Rh, Pd)
- 😞 No fuel flexibility
- 😞 Oil dilution penalty

Selective Catalytic Reduction

- 😊 European choice on HDV for EURO 4
- 😊 High efficiency (NH_3/NO_x)
- 😊 Fuel efficiency / Lower GHG emissions
- 😊 Better durability
- 😊 Fuel flexibility (S insensitive)
- 😊 Adaptation for mobile sources (transient regimes)
- 😞 On-Board Extra-Fluid (Urea, as Ammonia source)
- 😞 Urea Infrastructure & Integration

Focus on SCR Technology + Noxcare™



Chemical & Physical Properties of Urea

- 32.5% ± 0.5% concentration in water
- Polymerisation of urea is not possible
- Clear, No smell
- Non toxic
- Not inflammable and no risk of explosion
- Freezing point : - 11°C (12°F)
- Corrosive

1 NOxCare tank, 2 Temperature sensor, 3 Fuel-level sensor,
4 Supply module, 5 ECU, 6 Metering valve, 7 Air-supply tank,
8 Exhaust-gas temperature sensor, 9 Exhaust-gas sensor,
10 Air supply, 11 Treated exhaust-gas, 12 Atomizer pipe

Material specificities

Material compatibility

- ➔ *Urea solution is corrosive*
- ➔ *Need of stable materials for tank, pipes and fittings*

COMPATIBLE	UNSUITABLE
stainless steel austenitic steel some aluminums plastics	unalloyed steel galvanized steel copper Brass



Comparison Plastic / Metal

Plastic is the good choice for future tanks/cartridges

	PLASTIC	METAL
Design flexibility		
Design cost		
Robustness		
Safety		
Weight		
Material compatibility		
Pressure/vacuum flexibility		
Integration		



Urea need a plastic tank for HD & LD

Selective Catalytic Reduction on Heavy Duty



European & US Technological Trends for Heavy Duty



- EURO IV** ▪ SCR has been chosen by HD OEM to meet Euro 5 limits (Introduction in 2005/2006 timeframe in a Euro 4 environment).
- EURO VI** ▪ Euro 6 target is SCR for cost, however, substantial SCRT or A-DPF penetration likely.
- LNT not considered for HD in Europe due to cost, fuel penalty, efficiency and durability.

- HD OEMs have decided to use high-EGR and CSF in 2007.
- No choice for US'10.

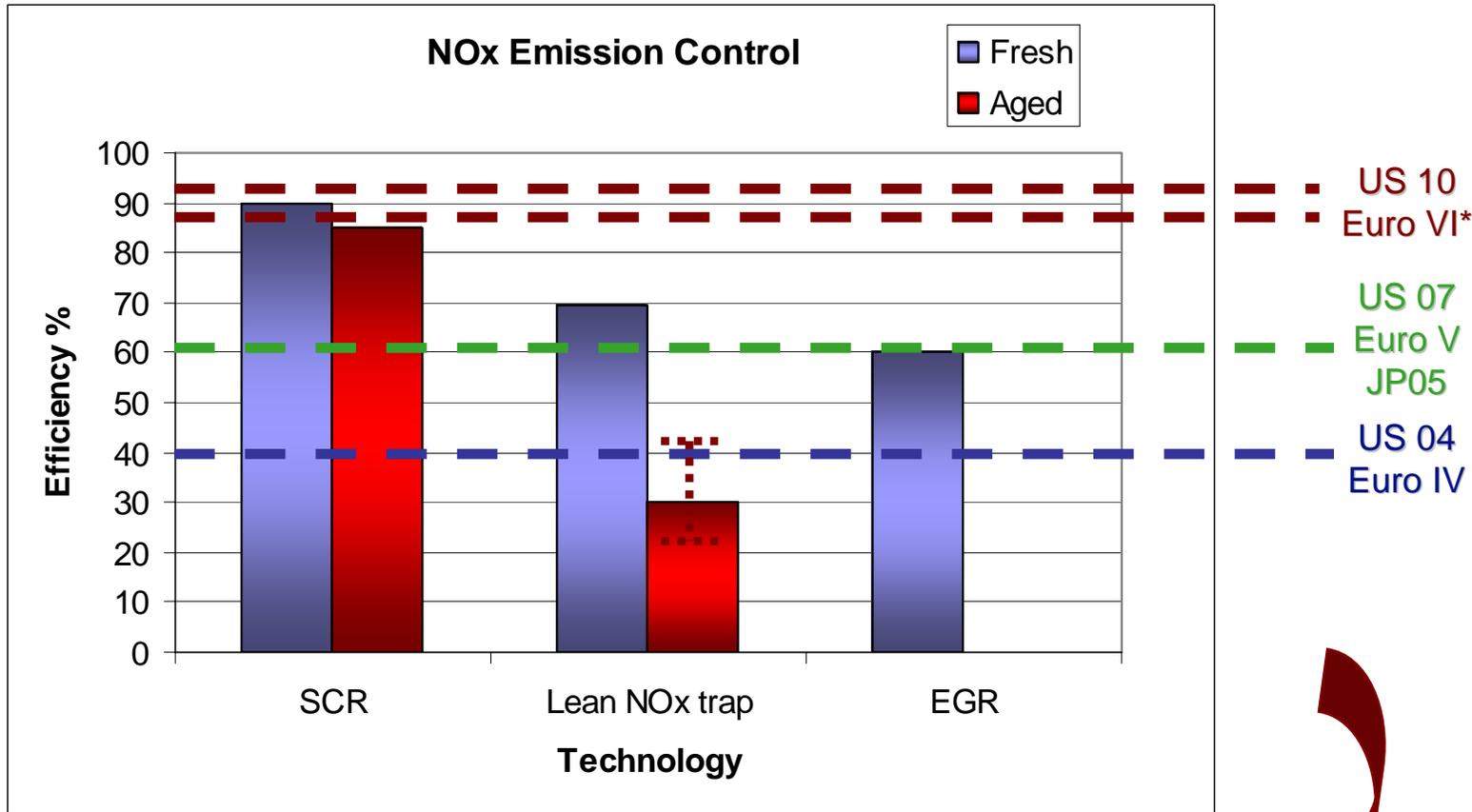
US'07

US'10

- LNT costs are expected to be higher to both the OEM and the end-user...Pt and fuel required for regeneration.
- SCR will always be more cost-effective when urea cost is less than fuel (urea target \$1.00/gallon).

**SCR CHOSEN in Europe – SERIOUS CANDIDATE in US
NO Lean NOx Trap developments anymore in EU**

SCR is the best technology to comply US10/Euro VI

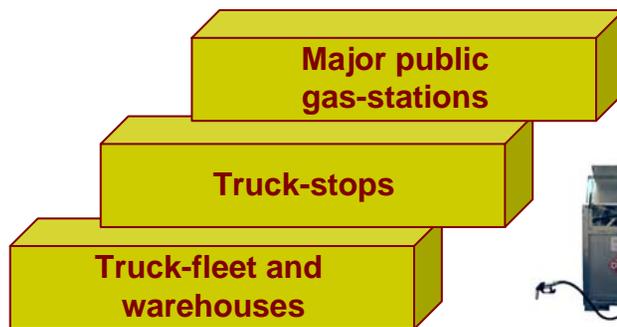


**SCR is the ONLY Technology able to comply EU VI and US'10 (depending levels, SCR will need low improvements)
If there is no breakthrough, LNT should disappear**

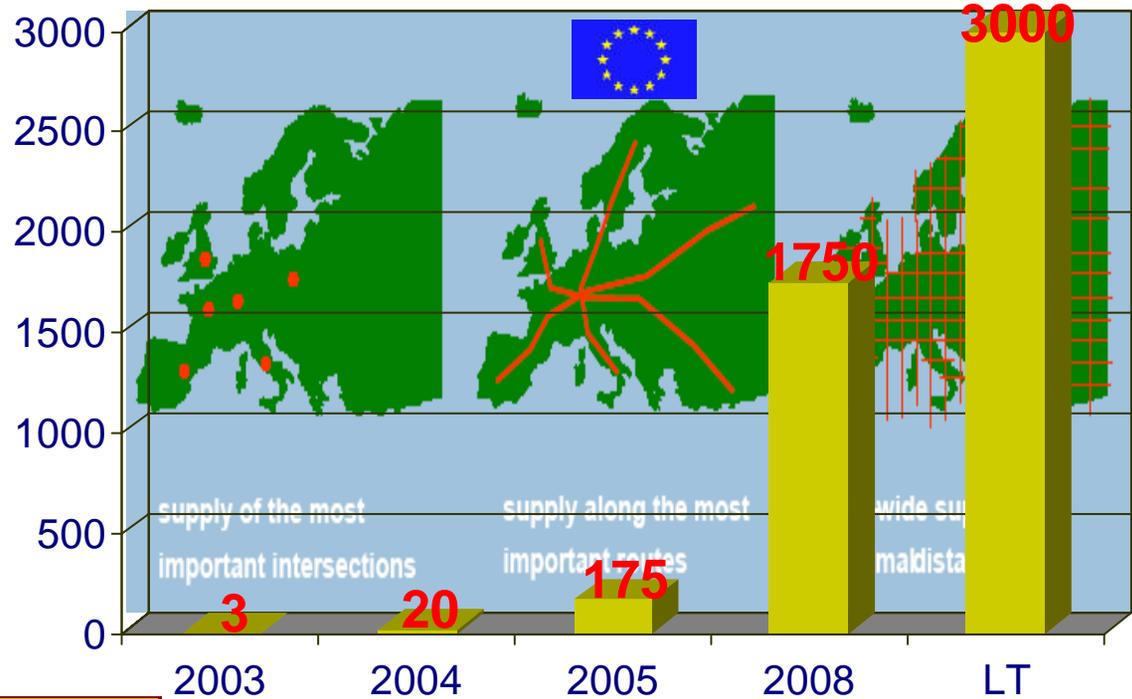
A Progressive implementation of the Infrastructure

- ➔ Present urea price at pump : €0,599
- ➔ OEM expectation : €0,45
- ➔ ACEA : €0,40

Volume
Noxcare



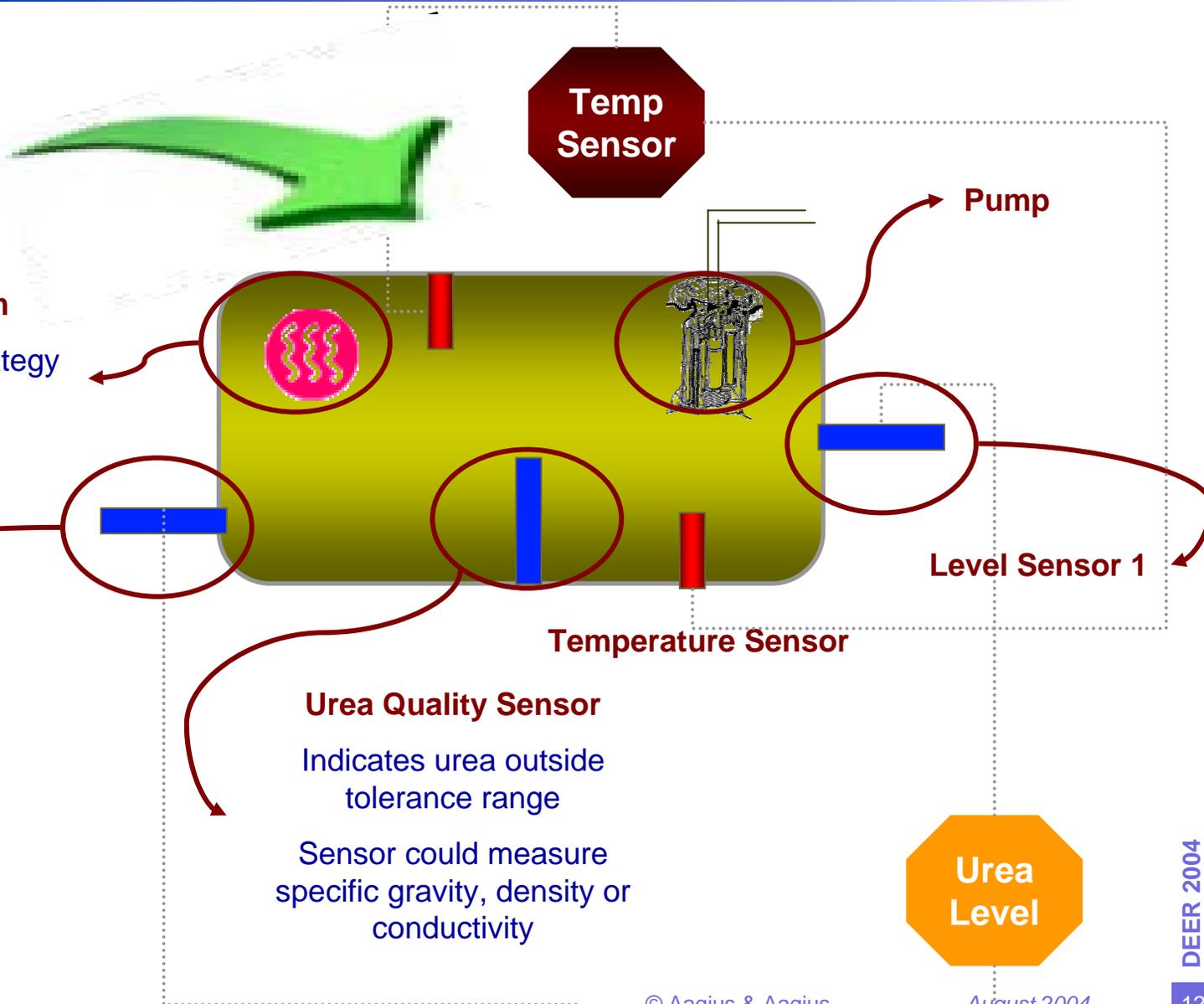
Time



Urea Pump

Sources : Total, Shell, Esso.

Go to Generation 2 : Plastic Urea Tank



Temp Sensor

Pump

Heating System

Definition of the strategy to heat the tank

Level Sensor 1

Temperature Sensor

Level Sensor 2

Urea Quality Sensor

Indicates urea outside tolerance range

Sensor could measure specific gravity, density or conductivity

Urea Level

Conclusion for SCR on HDV

Europe

- ➡ *For future NOx emissions regulations in EU & US, SCR offers a unique solution for the most severe.*
- ➡ *For SCR, main issues are going to be solved (integrated plastic tank, tank compatibility, material, infrastructure).*
- ➡ *The technology and processes necessary to SCR are available today even though infrastructure is not available completely.*

US

- ➡ *At present US can take position for 2007 – 2010 for SCR and take advantage of the global experience in EU.*
- ➡ *SCR could be initially rolled out in US for HDV with a limited infrastructure (like in EU).*

Selective Catalytic Reduction on Light Duty

European & US Technological Trends for Light Duty



- No clear Euro 5 scenario on LD as limits are not defined yet
- Three Euro 5 NOx scenarios identified:
 - ➔ „mild“: 0.18-0.20 g/km
 - ➔ „moderate“: 0.125 g/km
 - ➔ „aggressive“: 0.08 g/km
- If denoxation is required, SCR and LNT technology could be in use
- At present LNT not mature and a few perspective for future due to disadvantages.
- If Euro 5 NOx limits are „mild“ (2008), Euro 6 NOx limit will be „aggressive“ (2010 – 2012).



- European technology will be leveraged
- DCX has announced the introduction of an SCR system on the Mercedes E320 in low volume in 2007...Bin6

SCR is BEST CANDIDATE and MOST COMPETITIVE
in EU & US
Lean NOx Trap is FARAWAY
 (LNT need a breakthrough to survive)

Solutions Strategies for LD



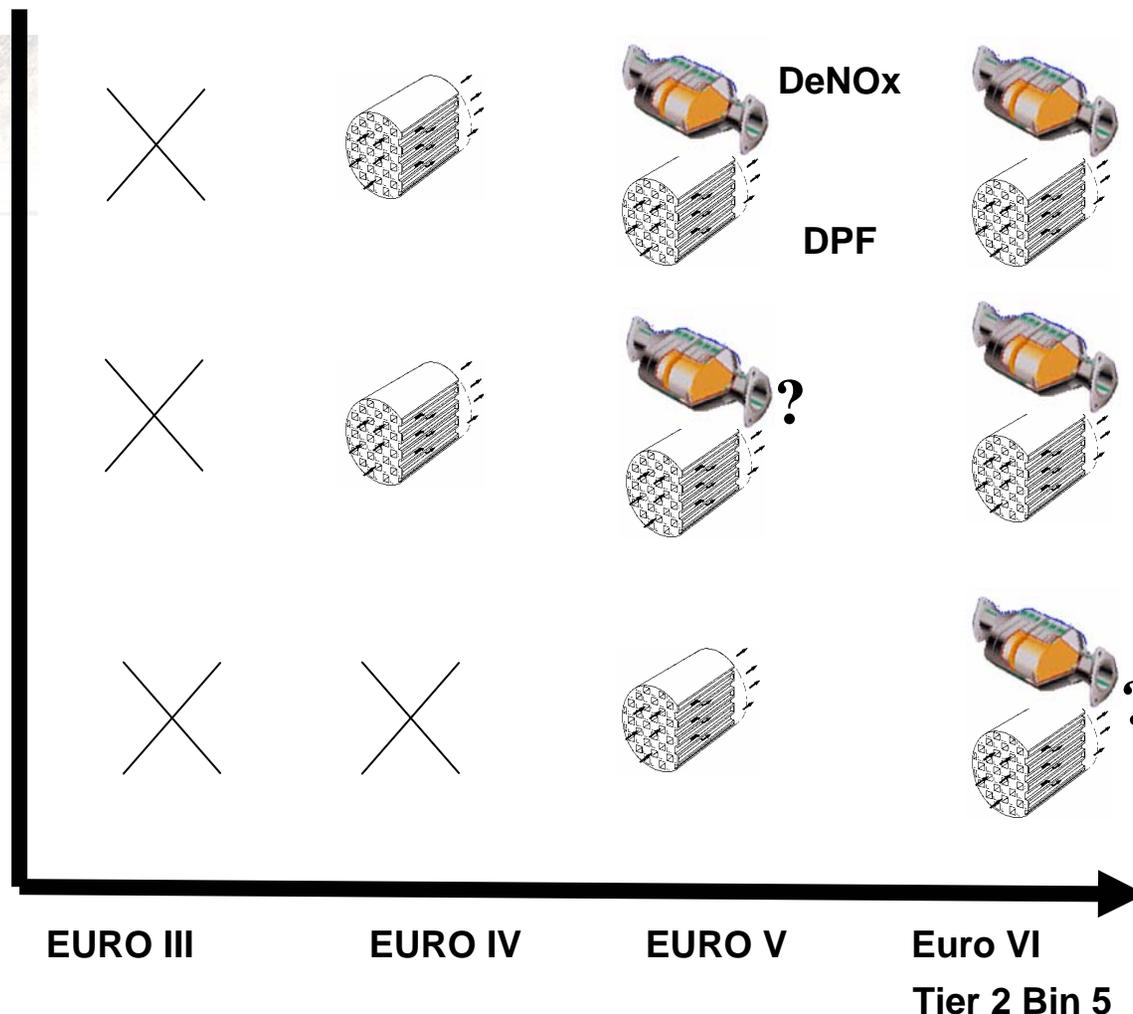
SUV & Executive



Mid-Size



Small-Size



From today viewpoint Combination of DPF and DeNOx Technology seems necessary

SCR is in progress on Light Duty Vehicles

All car manufacturers are working strongly on SCR solution for Euro V and Euro VI regulations :

Ford Focus demonstration with SCR :

Urea SCR can provide >90% NOx conversion required for US07 LDV & HDV standards with advantages / LNT :

- Wider temperature window
- Lower fuel economy penalty
- Lower usage cost
- Greater durability
- No oil dilution
- Lower system cost

*Ford Experiences
SAE 2004-01-1292
SAE 2004-01-1291*

Mercedes has announced :

E320 CDI turbo Diesel with SCR system in 2007 in US

*Mercedes
Press
Release*

View of Urea integration solution

Material
Plastic

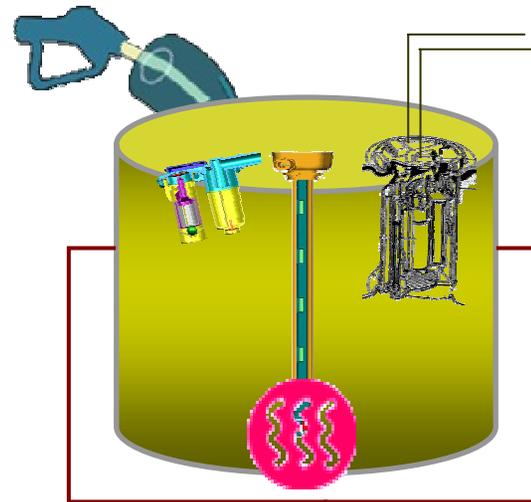
Filling
Classical
Co-filling/fueling
Dealer Service

Venting
Valves

Electronics
To calculate consumption//
Urea injection supply

Integrated inside FS perimeter
Supplementary tank
Integrated tank (supplementary
tank/double pocket/ INSAS for
refilling at trap)

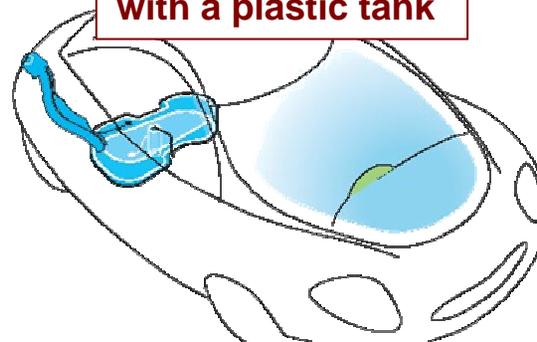
Global urea Vehicle integration



Feeding
Pump to supply dosing/injection
Pressure regulator
Lines (heated/purged)

Storage and level measurement
Heating
Temperature sensor
Level sensor
Urea quality sensor
Security device when empty

Vehicle integration with a plastic tank



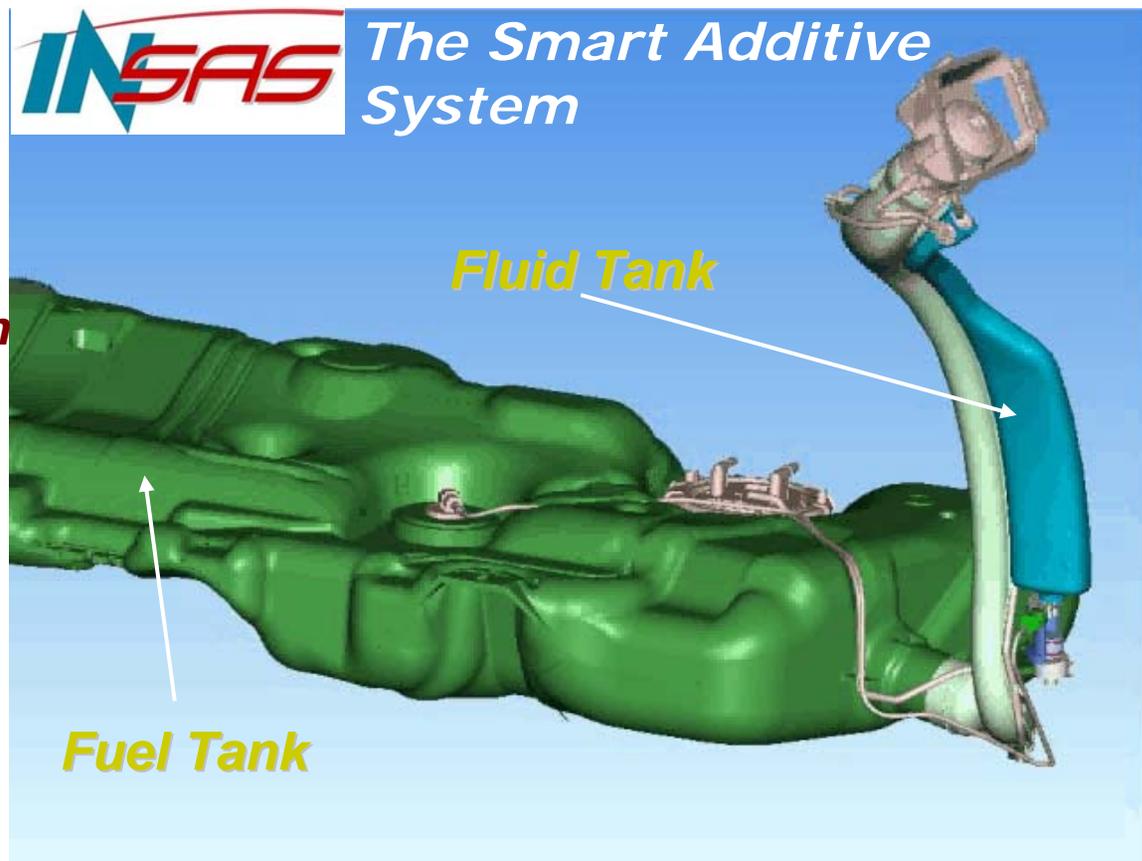
Integrated outside FS perimeter
Partnership to locate urea tank outside
FS perimeter with integrated functions
(solutions to refill at trap)

Integrated Fluid System : Easy and simple

Example for onboard
vehicle fluid :
Additive for DPF

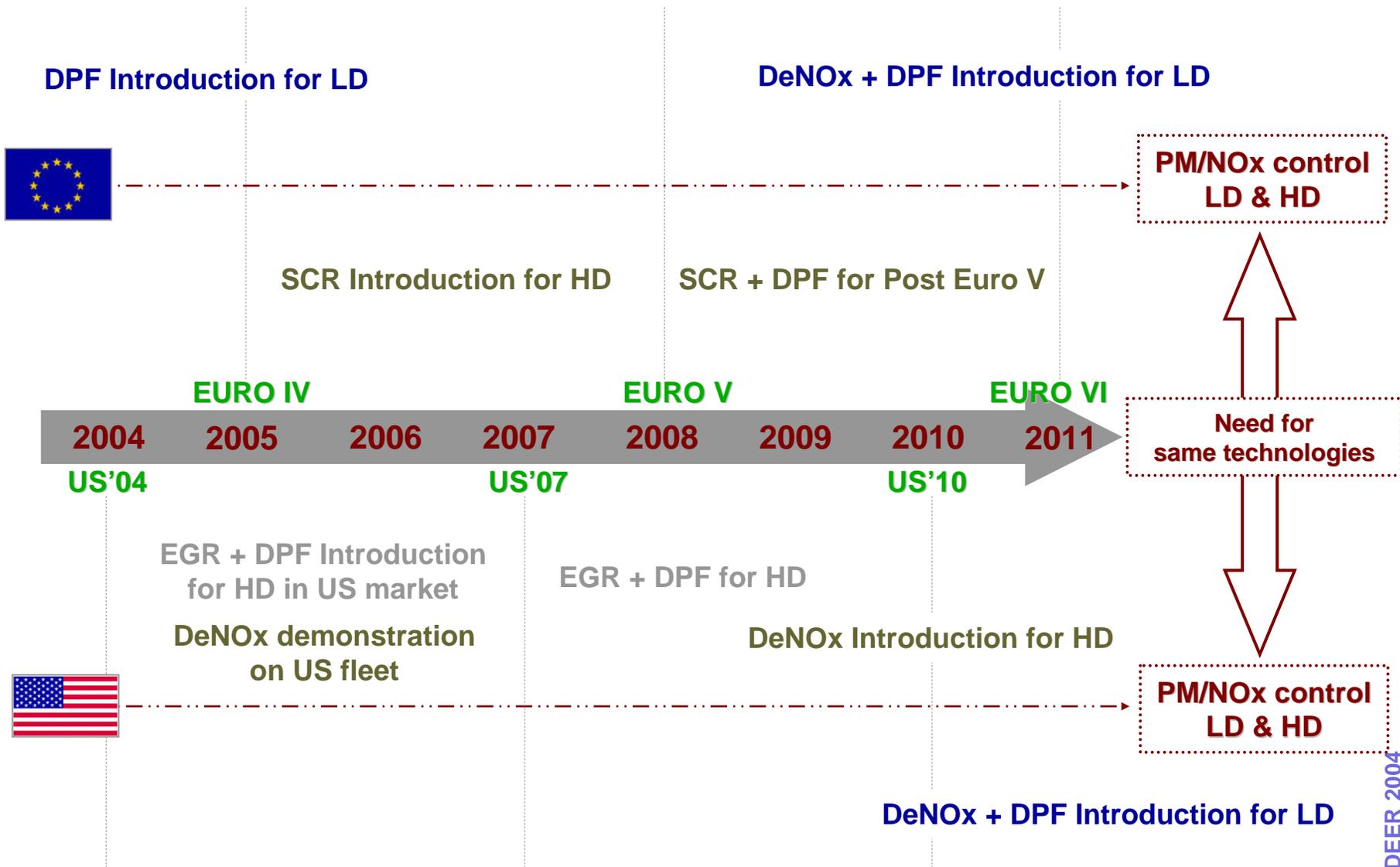
- ➔ **Flexible Design**
- ➔ **Integration simplification**
- ➔ **Lower cost**

Source : Inergy Automotive
Systems

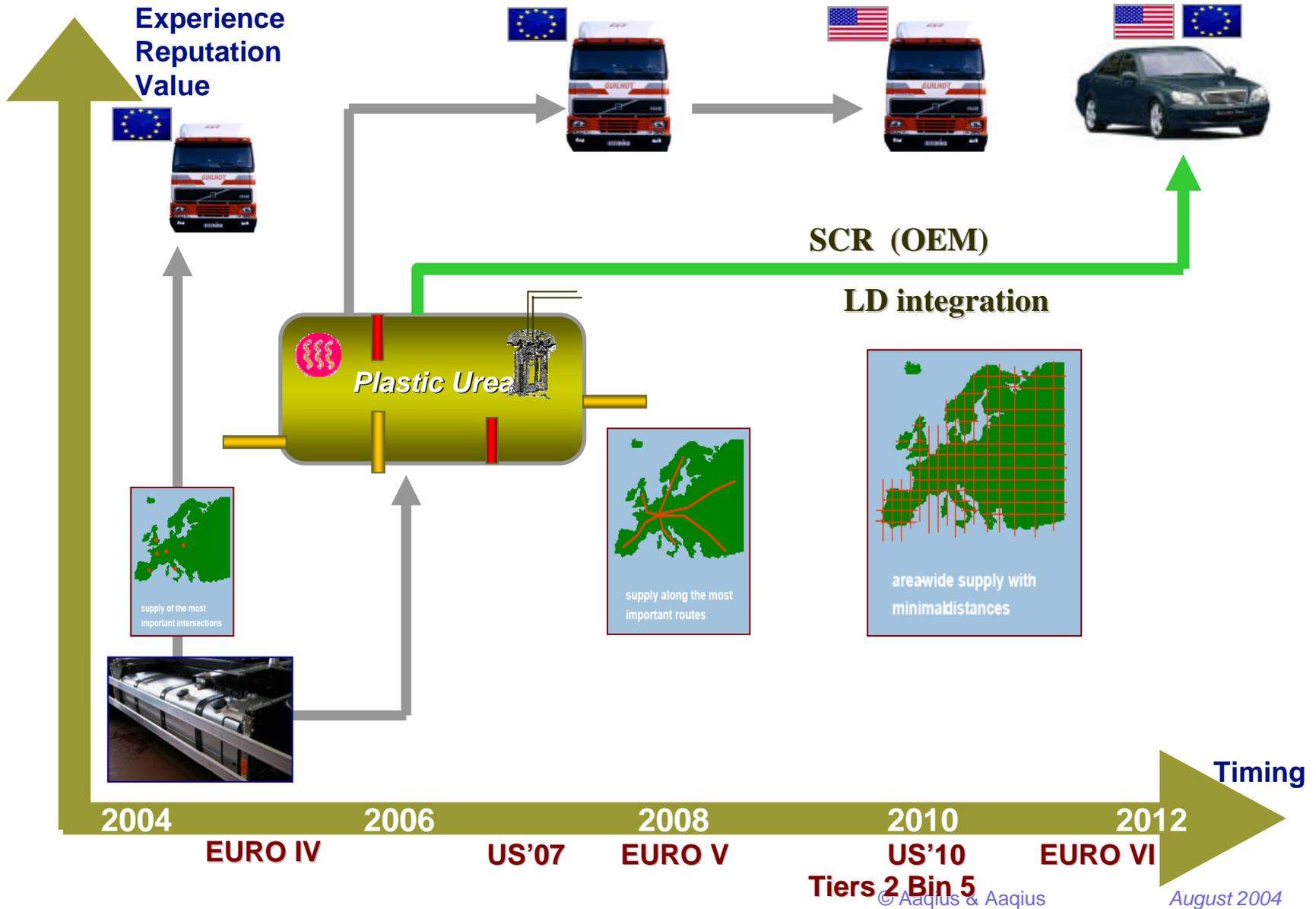


Conclusions & Perspectives for DeNOx market

2010-12 : The need for the same technology



Perspectives for SCR : A Global Strategy



Conclusion & Perspectives

Main issues are going to be solved for SCR :
(mains actors are taking position for SCR)

- ⇒ *integrated plastic tank for better design integration*
- ⇒ *Compatibility materials*
- ⇒ *Infrastructure and filling/ refilling*
- ⇒ *Better strategy for Urea injection.*

For future emissions regulations in EU & US, SCR in combination with DPF offers a unique and global solution for the most severe regulations :

- ⇒ *CO2 emission will be an issue for the next decade : With SCR fuel consumption are lowest.*

For future emissions regulations in 2010 - 2012, EU & US could use the same technology to comply emissions regulations.

- ⇒ *EU & US have to work closely in order to define standard for SCR.*

OEMs target cost is a major point :

- ⇒ *For NOx & PM regulations the lower technology cost will be the favourite candidate.*
- ⇒ *For NOx regulations, SCR technology is 2 times less expensive for LDV and 3 for HDV (Ford SAE 2004)*



*Thank you
for your attention*

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