SCR – An AGCO Perspective

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IAgrE Landwards Conference

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Cranfield University ,UK

About AGCO

- Founded in 1990
- 100% Agriculture equipment company
- 2,800 independent dealers and distributors, in more than 140 countries
- Headquarters located in Duluth, GA, USA
- Producing Engines in Finland – AGCO SISU Power
- Purchasing Engines from Perkins and Deutz
- Producing Agricultural Machinery in predominantly 4 Brands.

AGCO Brands:

Challenger	Exclusive brand for the Caterpillar network	
FENDT	High tech solutions	
MASSEY FERGUSON	The world's leading tractor brand	
VALTRA	Completely customized performance	

AGCO Your Agriculture Company

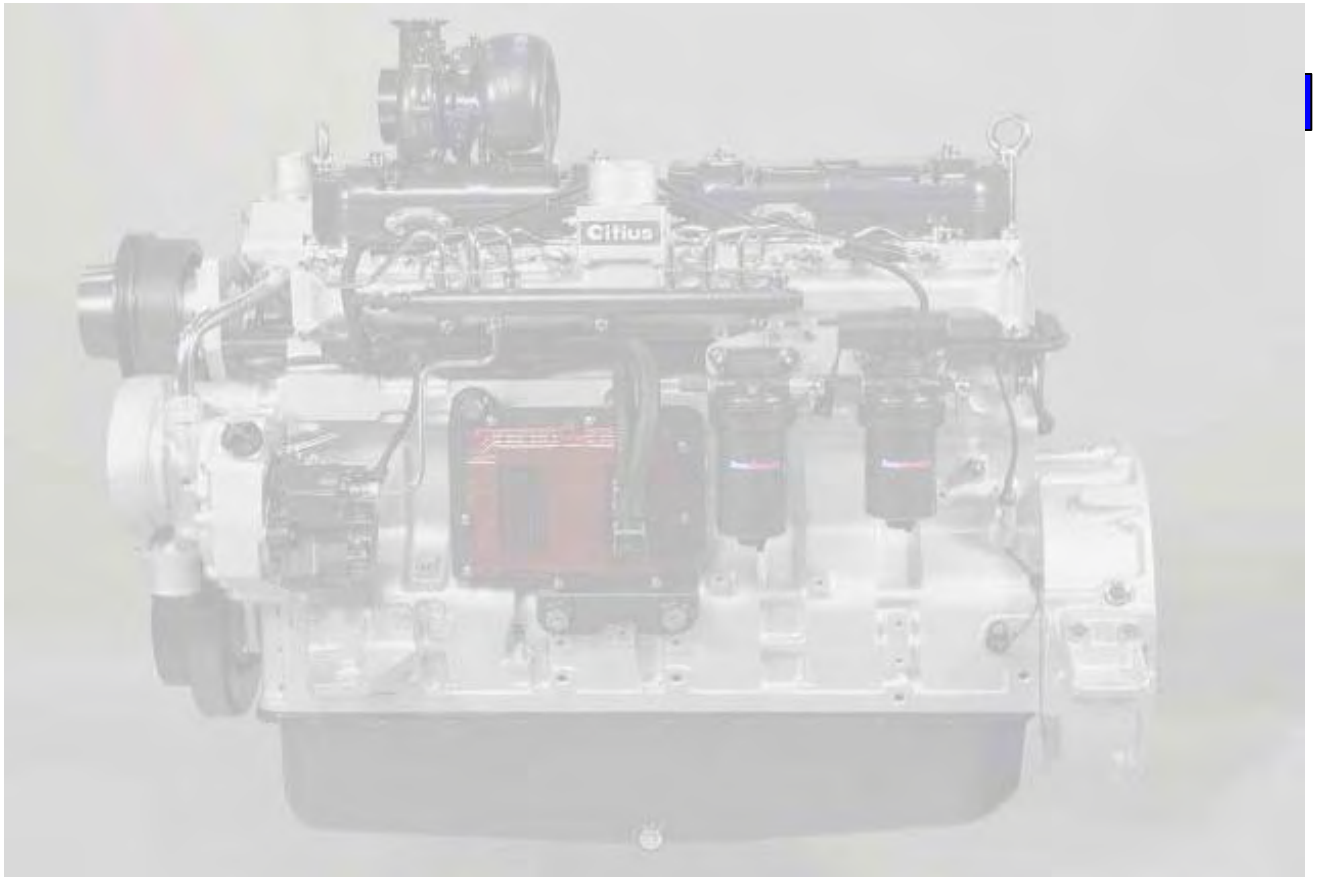
AGCO SISU POWER European Engine Factory in Nokia, Finland



- 10 hectares factory area, 3 ha buildings
- Over 60 years experience in diesel engine production

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SisuDiesel Tier3 Engine Range



	Torque in Nm
Type 84 - 8,4 litre	1.000-1600
Type 74 - 7,4 litre	750-1.150
Type 66 - 6,6 litre	500-950
Type 49 - 4,9 litre	400-750
Type 44 - 4,4 litre	300-650
Type 33 - 3,3 litre	250-450

0 50 100 150 200 250 300 350 400 450

Gross Power Hp

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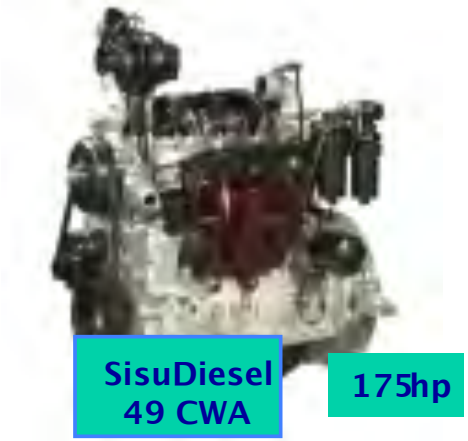
AGCO SISU POWER – Common Rail Engines



SisuDiesel 33 CTA — 100hp



SisuDiesel 44 CWA — 160hp



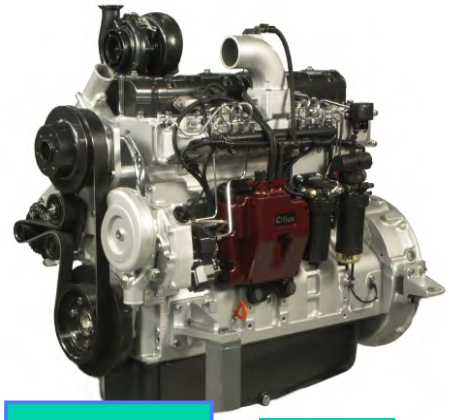
SisuDiesel 49 CWA — 175hp



SisuDiesel 66 CTA — 230hp



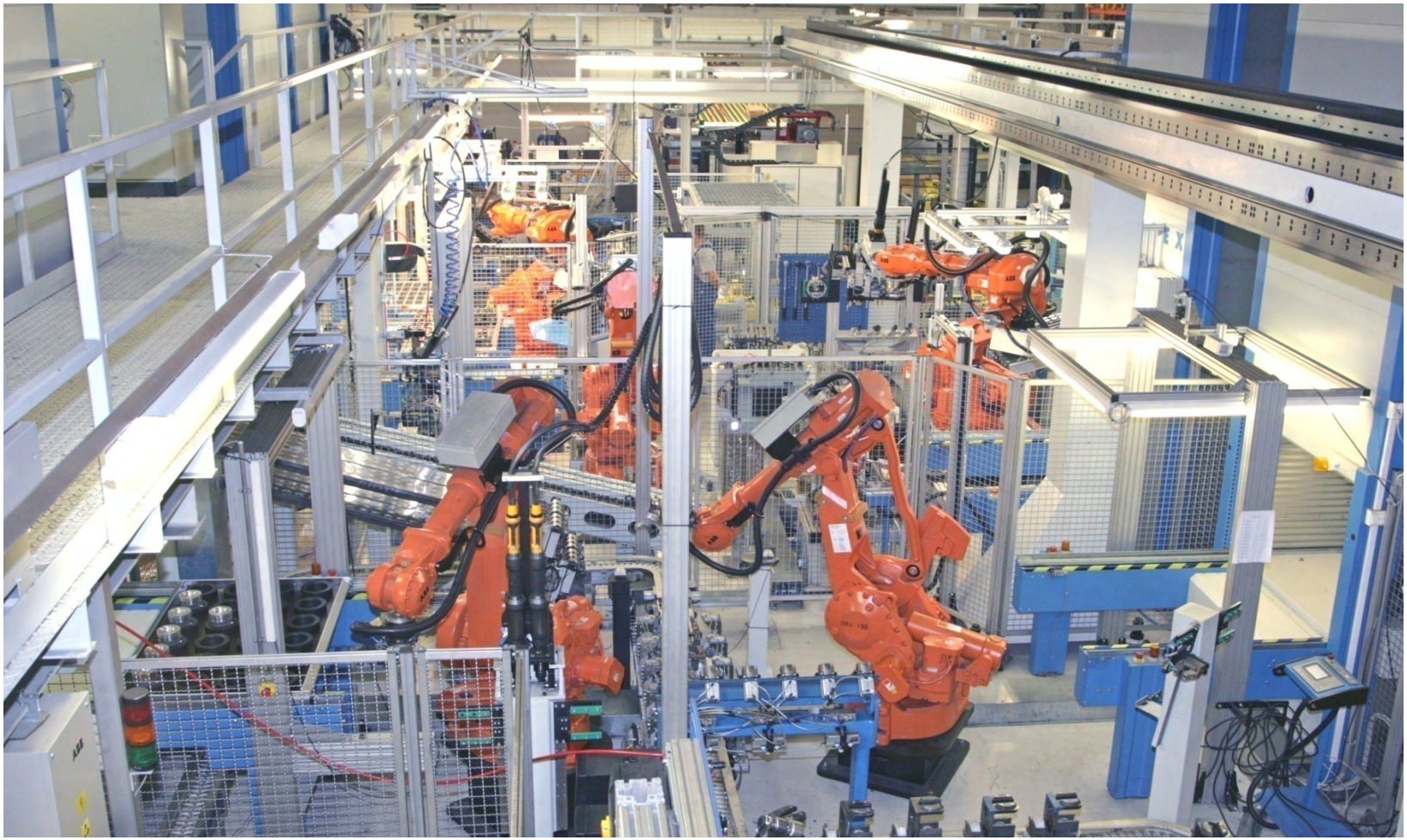
SisuDiesel 74 CTA — 280hp



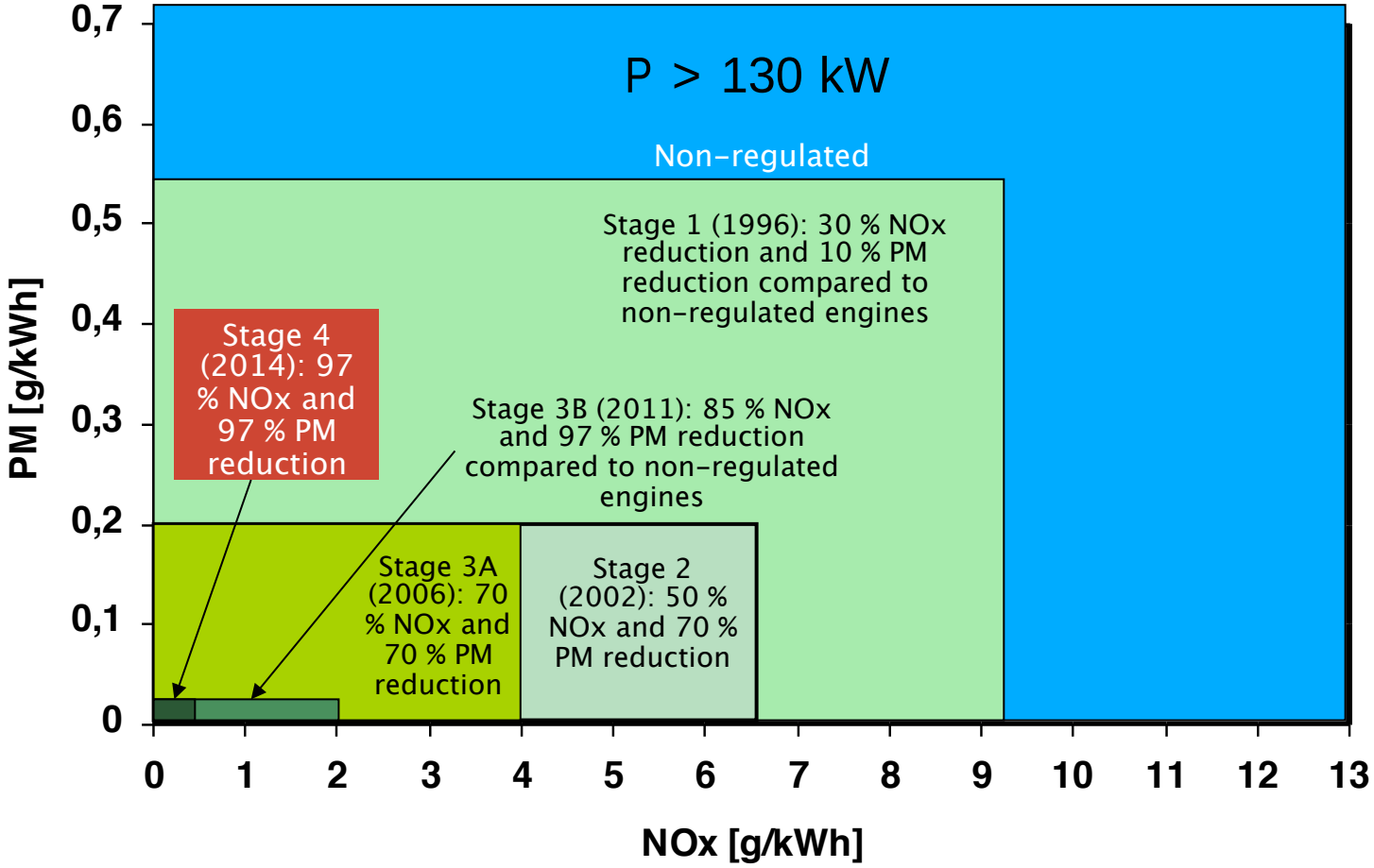
SisuDiesel 84 CTA — 420hp

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AUTOMATED – Engine Assembly



Taking on the Stage 4 Challenge of NOx and PM reduction



Emission Technologies – Road to Stage 4 required a choice



What would be the Best Route?

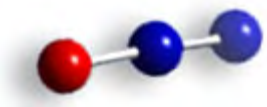
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What could be the Best Route?

- In Stage 4 final
  - NOx drops to 0.2g
  - PM is driven to low levels at Stage 3b

- How could manufacturers achieve this?
  - Choice 1 – Cooled EGR: Technology where re-circulated exhaust gas lowers the temperatures inside the cylinder during the compression stroke and also decreases the airflow of the engine to reduce Nitrous Oxides.

  - Choice 2 – Urea SCR: Technology where a NOx reducing agent (a water solution of urea) is injected into the exhaust gas upstream of the SCR catalyst. The water evaporates and the remaining ammonia sets off a chemical reaction eliminating NOx and leaving only nitrogen and water in the exhaust.



Considerations for the Choice – Technical considerations

- Overall Machine Cost and HP Targets For The Future had to be Achieved….
  - EGR held Technical Challenges for cooling configurations and packages.
    - Major impact on cooling package height to achieve similar power as SCR
    - Estimated height would mean that water radiator height would go from 700 to 850mm.
    - The hood and the cab would have to go up by the same thus reducing visibility, turning radius, and other performance limiters.
    - Product cost would therefore also adversely affected.
  - Higher HP targets could be achieved using SCR without additional Cooled EGR Constraints.
    - Increase cooling power by 10% without cooling package enhancements.
  - With SCR base combustion can be optimised with good fuel economy, low particulate and low heat rejection, but producing some amount on NOx emission
- In summary Key advantages of SCR base technology comparing to EGR were seen as:
  - Better fuel economy
  - Lower heat rejection
  - Less PM and smoke
  - Less soot contamination to lube oil – longer service interval



Considerations for the Choice – Commercial considerations

- Europe and the EU
  - Urea based technology already “known”.
  - Widespread in the on-road markets.
  - Urea distribution infrastructure not mature, but established.
  - Customers and users already understand the benefits.
  - Fuel Prices and input costs have been a major part of the farmers buying decision.

- US and Canada
  - Urea based technologies knowledge not widespread.
  - On-Road truck markets were increasing awareness but slowly.
  - Urea distribution infrastructure not present.
  - Need to educate customers on benefits.
  - Fuel prices not stable and input concerns high.



Considerations for the Choice –Other Pros and Cons

- Possible Implications of Choosing SCR Path
  - Non-Urea Technologies still available at Stage 3B
  - Machines requiring AdBlue could be orphaned.
  - Machines requiring AdBlue face competitive disadvantage of requiring second fluid.
  - Urea supply infrastructure not established.

- Possible Implications of Choosing a Cooled EGR Path
  - Machine development could be delayed by using EGR only for Stage3b, since SCR would almost certainly be needed eventually anyway.
  - Competitors take initiative and move to Urea based technologies and promote fuel economy savings.
  - Impacts to engine designs for the future.
  - Redesigns of cooling components and Hood envelope on existing machines driving higher costs.



Based on "What We Knew" AGCO Chose SCR

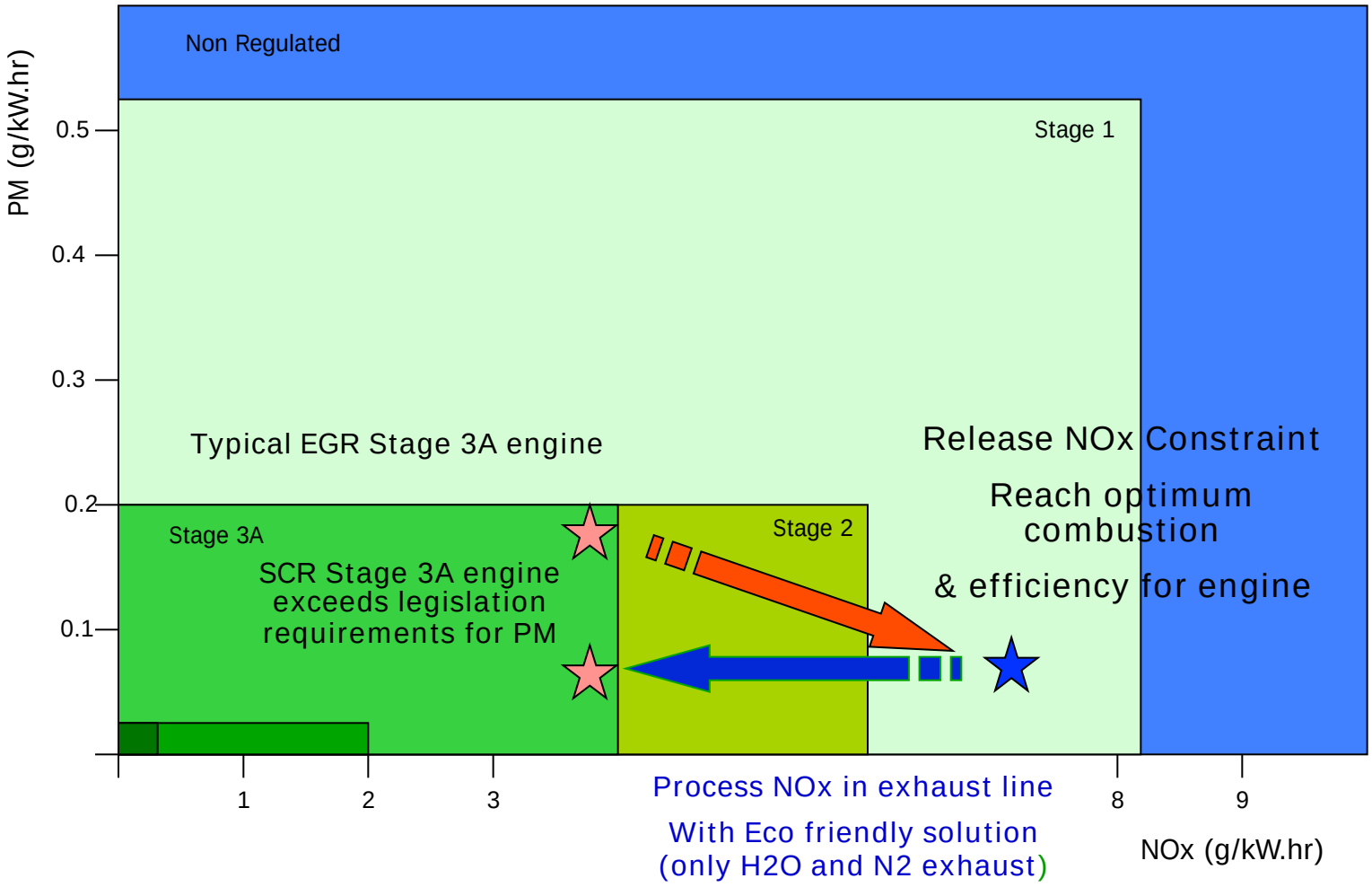
- **Why?**
  - AGCO SCR will improve the thermal efficiency of the diesel process. (The engine will be fully tuned to utilise the fuel and convert it to horse power, with the SCR system managing the emission levels in the exhaust pipe).
    - This results in lower total operational costs for the end user.
    - This results in lower development costs due to packaging coolers and constraints.
  - The SCR system on a SISU Diesel Engine will consist of a system of components that sprays the urea solution to act as a reagent to reduce NOx in an 'exhaust gas after-treatment system' attached to the vehicle's engine.
    - No effects to the engine design.
    - Treats the exhaust "after" the emissions are released by the engine.
    - Allows Tier II versions to easily be available (less SCR components) for non-compliant markets.
    - Green technology that converts harmful emissions into harmless Nitrogen and water.
  - AGCO has chose to call this complete system and Process – e3

What is e3?

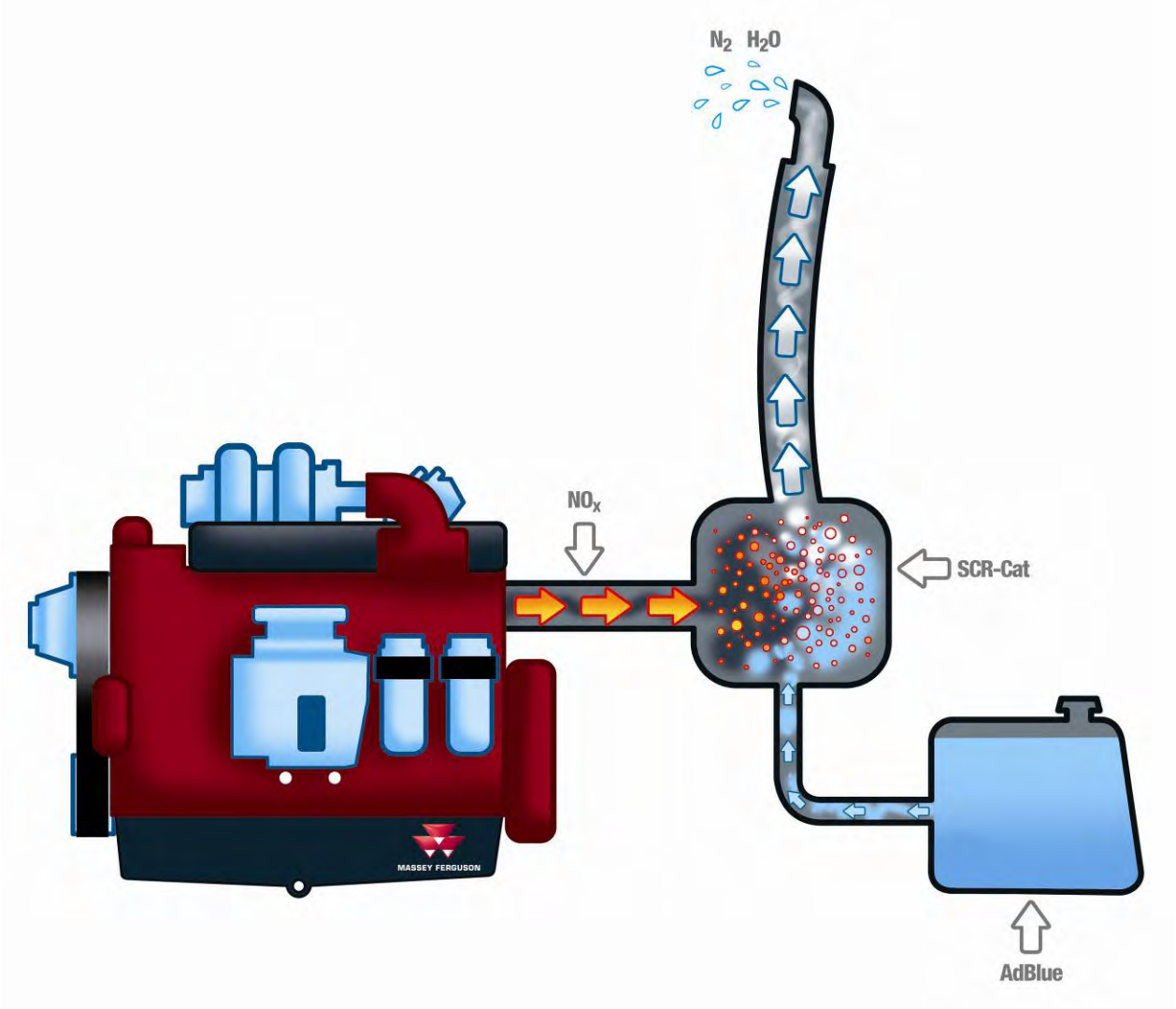
- e3 is the technology name that AGCO has chosen to describe SCR technology in AGCO SISU Power Diesel Engines:
- e3 promises to deliver the following:
  - ENERGY:
    - Uncompromised horsepower and torque
    - Cooler running engines.
  - ECONOMY:
    - Significantly improved fuel economy.
    - Reliable performance.
  - ECOLOGY:
    - Improvements to diesel emissions that not just meet regulations, but exceed them.
    - Technology that is helping to improve air quality without impacting performance.



SCR – Applied


Non Regulated
Stage 1
PM (g/kW.hr)
0.5
0.4
0.3
0.2
0.1
Typical EGR Stage 3A engine
Release NOx Constraint
Reach optimum combustion
& efficiency for engine
Stage 3A
SCR Stage 3A engine exceeds legislation requirements for PM
Stage 2
1
2
3
8
9
Process NOx in exhaust line
With Eco friendly solution
(only H2O and N2 exhaust)
NOx (g/kW.hr)

An Elegant Solution



Even Better when fully installed on a Massey Ferguson Tractor



Bosch Boxberg 2008 – The Worlds first SCR Tractor among its peers



Educating the Press



TRUCK and TRACTOR





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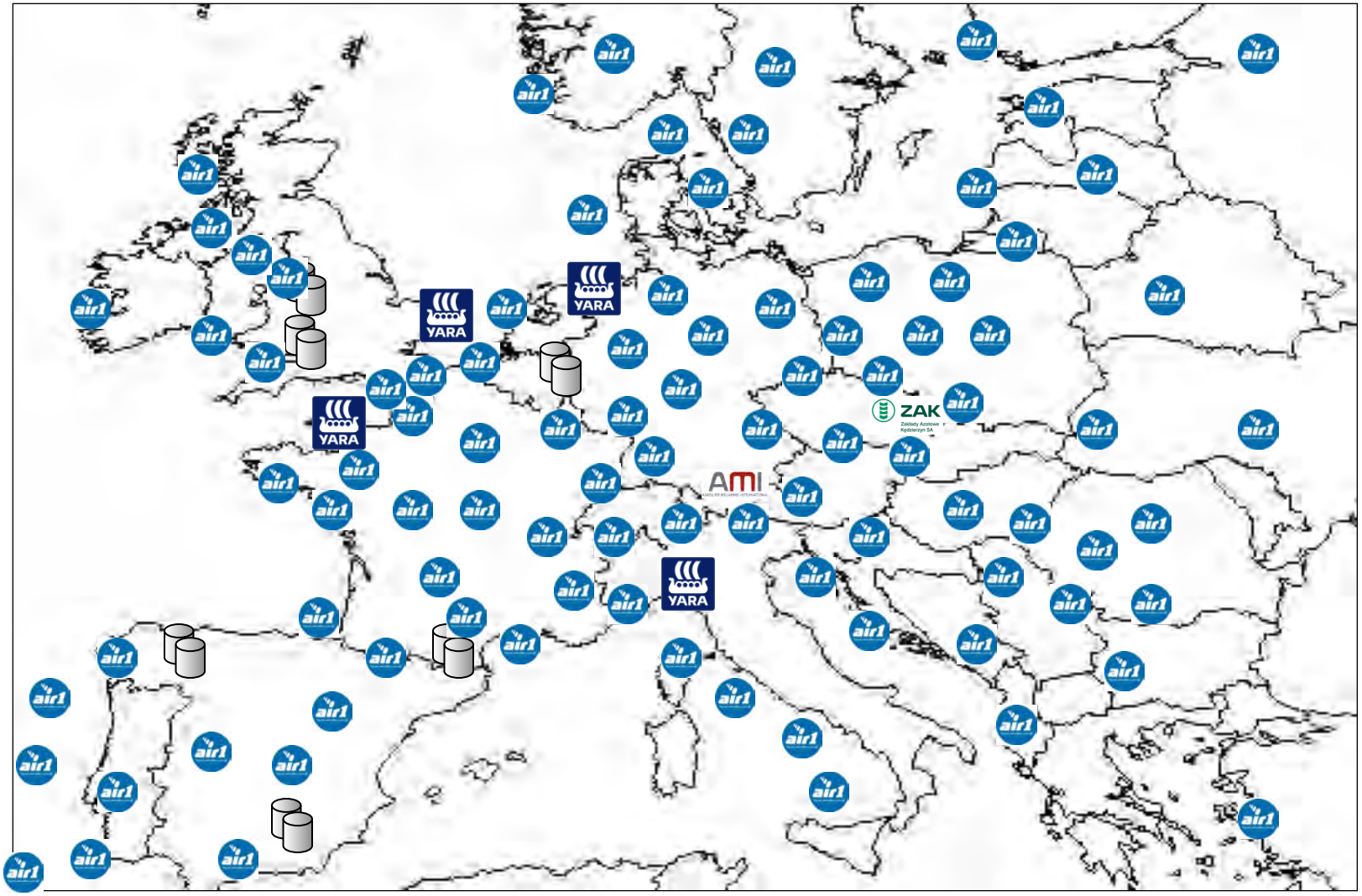






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In Europe :



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The Ultimate Accolade – MF 8690 SCR Powered tractor Wins Tractor of the Year 2009



EPA Approval – A final challenge

- Because of the newness of the technology, EPA approval was challenging for both AGCO and the EPA.
  - On-road strategies were very new or decisions to approach 2010 rules with SCR were very recent.
  - EPA understanding of SCR technologies were limited due to the newness of the technologies use in the US market.
  - EPA guidance document must be followed.
  - AGCO and the EPA agreed to many support requirements to ensure support and DEF were readily available to customers.
  - AGCO is leading many efforts to promote SCR use off-road and will become more of a player in many SCR and DEF stake holding organizations.

AGCO e3 Support in North America

- DEF / AdBlue is available through AGCO Dealer Parts
- DEF / AdBlue is supported by AGCO Answers (US Only) and the e3 website.
- AGCO Academy has incorporated Dealer and Customer training programs for e3.
- Independent test results (OECD Reports) confirm substantial fuel economy improvements vs. current AGCO products and other tractor manufacturers.







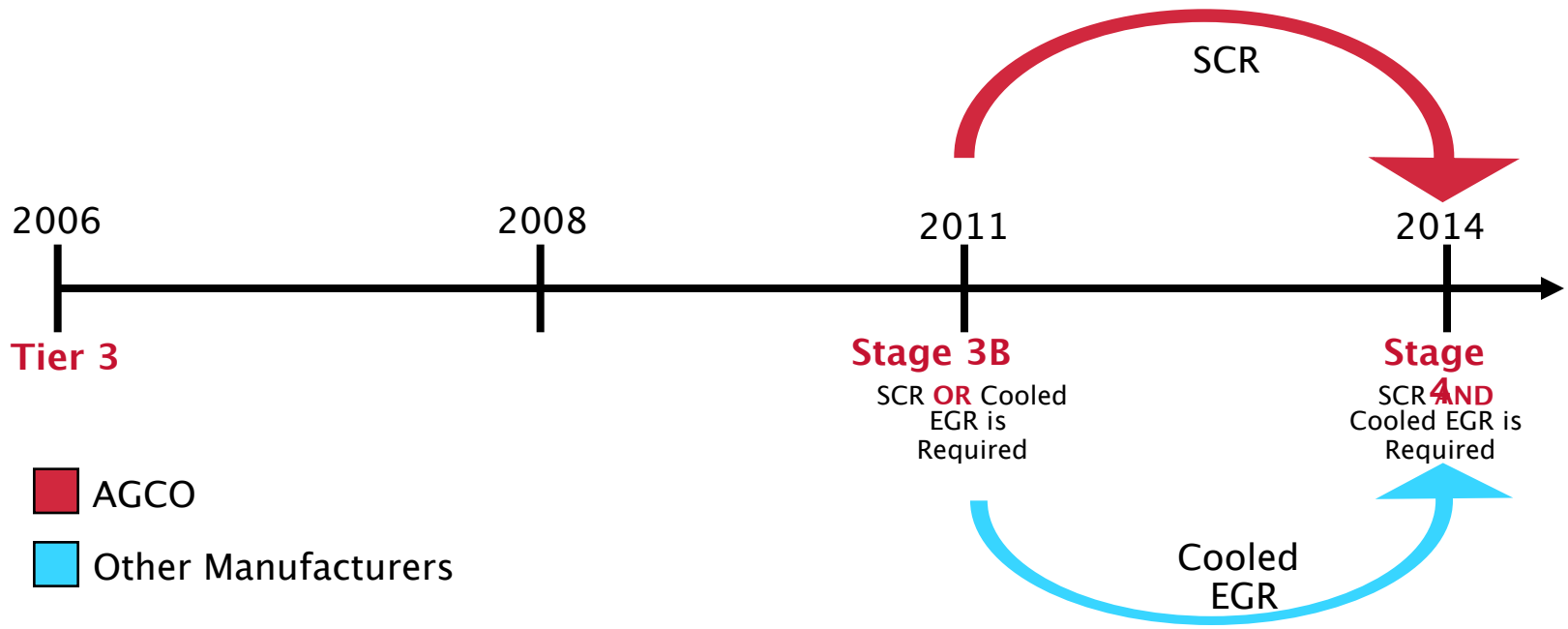
Emission Technologies – Where does the road lead next ?



Beyond Tier 4 do we even know where we are going?

Considerations for the Choice

- Based on what we know today, In Stage 4 final it may take both technologies to achieve compliance. Most manufacturers appear to be planning for this even though they may take different approaches in Stage 3B.



AGCO continues with SCR only for Stage 3B



An even more elegant solution.

Selective Catalytic Reduction (SCR) process with the Diesel Oxidation Catalyser (DOC)

01. The exhaust gases leave the turbocharger and enter the DOC cylinder.

02. The exhaust gases go through the Diesel Oxidation Catalyst (yellow). Carbon monoxide (CO), gaseous hydrocarbons (HC) and unburned fuel and oil (PM) are caught here. Nitrogen oxides are prepared to react with the urea.

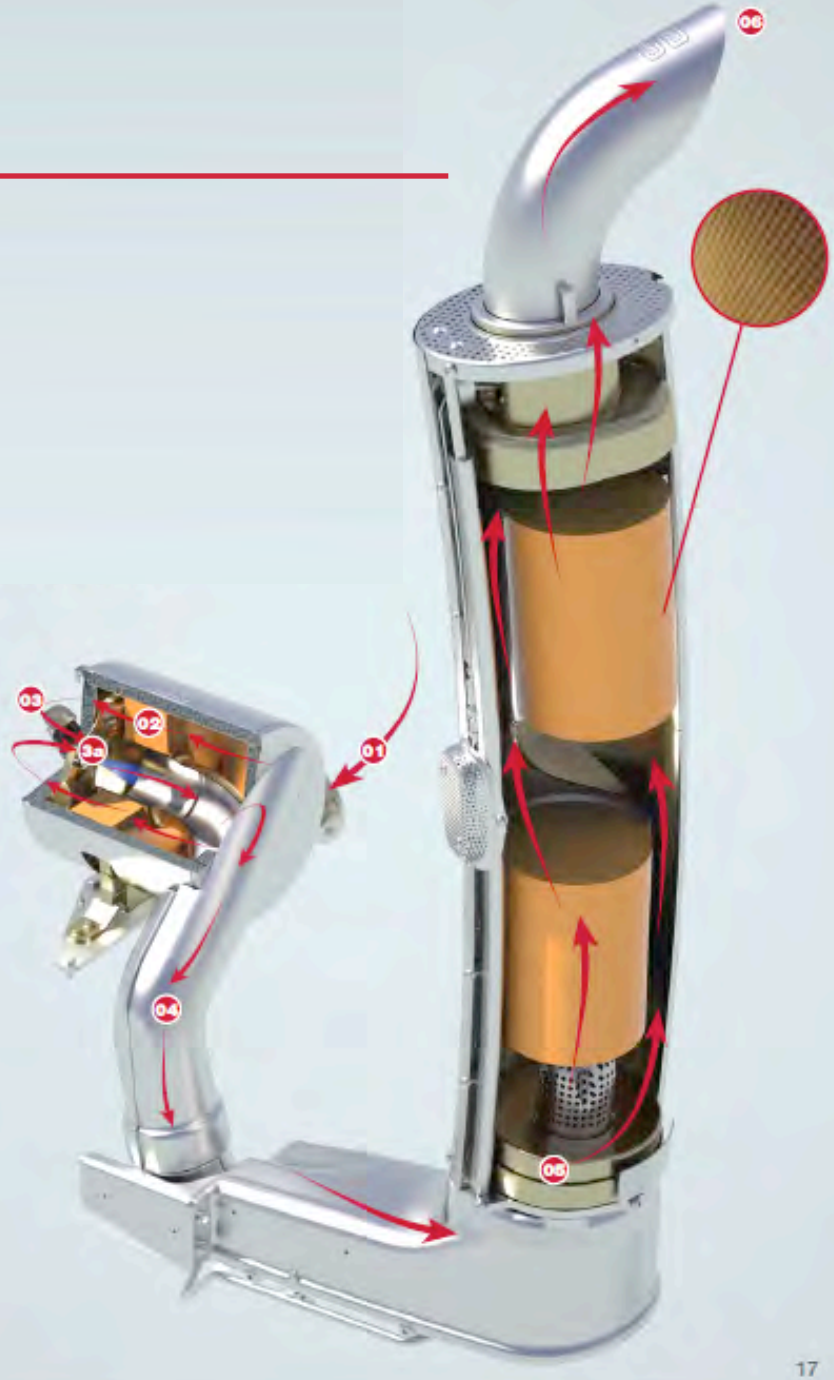
03. Urea injection occurs.

3 a. During this time, the exhaust gases leave the catalyst and return through the centre of the cylinder.

04. The gases that have mixed with the AdBlue leave the DOC cylinder to reach the exhaust pipe which contains two catalysts.

05. As the gases pass through the two catalysts and two slip-catalysts, the NO^X is converted into harmless nitrogen and water. The parallel use of two catalysts and slip-cats reduces the diameter of the exhaust pipe, thereby providing excellent visibility and access to the engine whist ensuring maximum emission control.

06. Clean air leaves the exhaust pipe.



The future – the only thing that is certain

- Emissions certification and controlling emissions will continue to be a substantial part of new product technology and new product development for off-road manufacturers in the short and long term.
  - NOx and Particulates now
  - Carbon Next?
  - And then?
  - We must be prepared to support as the technologies develop faster than the market support structures.
- The uses of off-road machinery continues to expand and new markets and applications emerge.
  - This will continue and the industrialization of BRIC markets and others grow and strive to feed and support themselves.
- We are also driven by customer requirements and legislative requirements in parallel.
  - This requires a delicate balance.
  - Will require OEM's and Engine suppliers to cooperate more.
  - Whatever path we follow we all need clearer standards and cooperation between governments and legislative bodies around the world.



Thank You