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Transportation

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Main Partner(s)

Johnson Matthey, Caterpillar and Loughborough University supported by the Energy Technologies Institute (ETI)

Part of the ETI's Heavy Duty Vehicle Efficiency Programme

Chris Thorne, Chief Technology Officer – Heavy Duty Vehicles

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Transportation: Delivering the High Efficiency Selective Catalytic Reduction (SCR) Project

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Content

- Project scope and desired outcomes
- Project approach and key elements
    - Technical approach
    - Team profile
- Why was collaboration so important to this project
- Project outcomes
- Impact potential of the project

Project scope and desired outcomes

The ETI is a public-private partnership between global energy and engineering companies and the UK Government delivering:

- Targeted development, demonstration and de-risking of new technologies for affordable and secure energy
- Shared risk

ETI runs a Heavy Duty Vehicle (HDV) Programme to develop and demonstrate de-carbonization technologies in on-highway and off-highway vehicles as well as marine vessels

The Selective Catalytic Reduction (SCR) project was one project within the HDV programme portfolio

Targeted a 3-4% fuel efficiency benefit and hence green house gas benefit from this project whilst exceeding emissions standards

SCR fitted to every truck and large off-highway machine sold in the EU and many newer cars

energy technologies institute

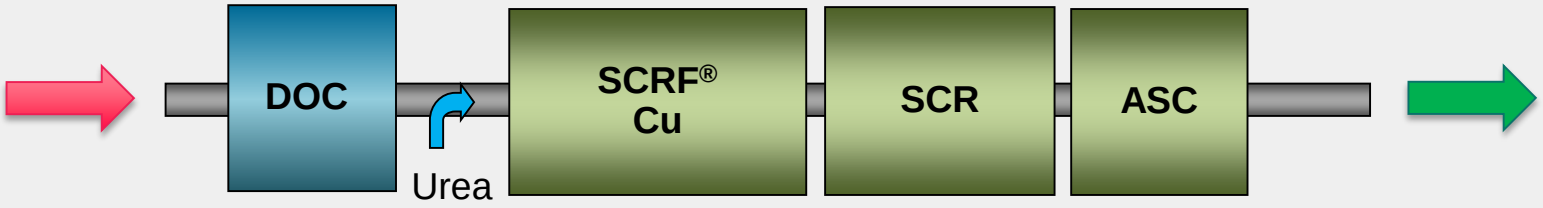
ETI members

bp
CATERPILLAR
EDF ENERGY
Rolls-Royce
Department for Business, Energy & Industrial Strategy
EPSRC Pioneering research and skills
Innovate UK Technology Strategy Board

What is Selective Catalytic Reduction (SCR)

Catalytic reduction of Oxides of Nitrogen (NOx) to nitrogen, water and CO2 using Urea as the reductant:

$$4NO + 2(NH2)2CO + O2 \rightarrow 4N2 + 4H2O + 2CO2$$



DOC = Diesel Oxidation Catalyst
SCRF = SCR on wall flow filter
ASC = Ammonia Slip Catalyst

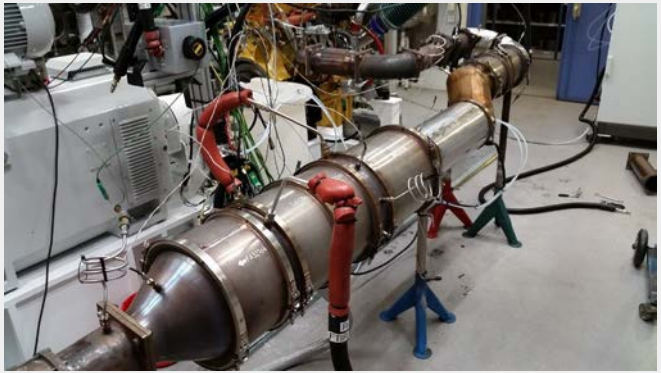
NOx is indirectly proportional to fuel consumption….hence better NOx reduction can be converted into better fuel economy…

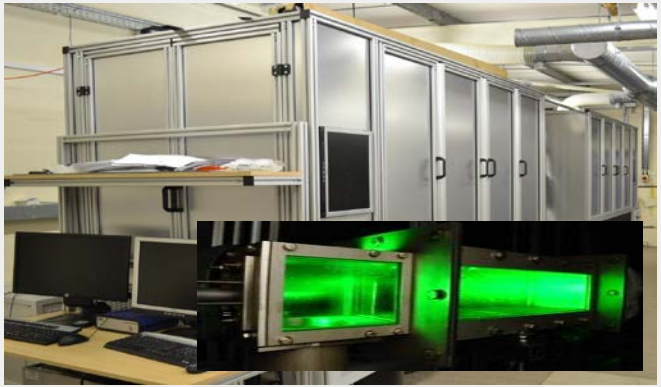
Project approach and key elements

- ETI invested in the project through a public request for proposal and subsequent contract
- Requested a SCR system capable of achieving a 98% reduction in NOx whilst not exceeding the space requirement and delivering a superior cost to own to the end user
- SCR technology must be applicable across a range of vehicle types and usage cycles
    - Light usage vehicles and machines are the most challenging
    - Lots of developmental solutions – little science based engineering…
- Selected a consortium made up from **Johnson Matthey, Caterpillar and Loughborough University**

Project approach and key elements

- Team profile:
    - Johnson Matthey – project management, catalyst selection and supply and system testing
    - Caterpillar – system integration and control system design
    - Loughborough University – mixing system research and design
- Complementary and complete skill sets key
- Clearly defined problem – clear sense of purpose





Project approach and key elements

- Technical approach
    - Wide initial solution space (circa 20 solutions)
    - Used industry experts to remove obviously poor solutions (down to 6 solutions)
    - System model to understand interactions, sensitivities and targets for the work elements
    - Innovation at system level and sub-system levels
        - Investment in UK university capability – 2 hot flow laser rigs
    - Selection via modelling to 2 solutions
    - Solution testing and final design
    - Verification of final design
    - Vehicle testing

Collaboration is key

- Interactive system comprising of complex chemistry, heat transfer, control problems and multi-phase fluid dynamics all happening over a vast array of timescales
- No one organization / person has sufficient in-depth knowledge and tools for all of the required phenomenon
- Had to collaborate
- System model an excellent framework with which to drive collaboration

Project outcomes and impact

- Achieved project objectives (3-4% GHG benefit at acceptable cost and package size) – applicable to any diesel engine!

- But many side benefits…
    - Stability and level of funding allowed for a more structured approach than industry or academia could support on its own – but they have seen the value…
    - Consortium members learnt lots from each other
    - Created a complete understanding of a pressing industrial challenge within an innovative academic environment
    - Plus provided necessary infrastructure to facilitate innovation

Project outcomes and impact

- Side benefits have led to further innovation by Loughborough University that solves the one of the remaining issue with Urea based SCR systems – cold temperature performance and deposits
- Loughborough technology is called ACCT
- This system allows the full capability of the catalysts to be used and completely eliminates deposits
- This is a game changing technology that has the potential to massively reduce inner city NOx emissions from diesel engines
- Again, applicable to every diesel engine!

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