CleanER-D
Clean European Rail-Diesel

Towards greener and cleaner rail diesel vehicles

Judit Sandor
Sustainability and Environment Manager, UNIFE

Roberto Palacin
Senior Researcher and Head of the Rail Systems Group, NewRail

Henning Schwarz
Senior Consultant, Environment and Sustainability, Deutsche Bahn Environment Centre

Christian Kamburow
IZT (Institute for Futures Studies and Technology Assessment)

Michael Meinert
Head of R&D Group Energy Storage Systems, Siemens AG, Infrastructure and Cities Sector

Rail is considered to be the most environmentally-friendly mode of transport. Rail exhaust emissions from rail diesel traction in Europe (EU27 & EFTA) are very low. Rail diesel traction accounts for less than 2.5% nitrogen-oxide and 4.5% particulate matters (EEA 2008[1]) out of the total emissions from the European transport sector. Nevertheless, continuous improvement must be ensured by the sector. This is to be underlined as the European railways committed to reduce their total exhaust emissions of NO_x and PM by 40% by 2030. To tackle the challenge of reducing rail diesel emissions, the railway industry launched CleanER-D – a research project partly funded by the European Union.

The main goals of the project are to demonstrate the feasibility and reliability of railway rolling stock powered with diesel engines compliant with the requirements of stage IIIB of the NRMM Directive. This objective is dealt with in the operational part of CleanER-D where two mainline locomotives have been selected to give the opportunity to test new engine concepts on existing vehicles.

The scientific part of CleanER-D has strongly focused on the socio-economic and environmental aspects of rail diesel applications. In this article, the consortium will guide you through the sustainability-related results that are presently available.

From 1990 to 2008, NO_x and PM emissions from rail diesel traction have already decreased by approximately 35%. Calculations by the CleanER-D consortium suggest a further substantial decrease of NO_x by approximately more than 20% and more than 25% for PM from 2008 to 2020. The estimates of total exhaust emissions will be based on more accurate and complete data and will be finalised in mid-2013. The reasons for this significantly better future emission performance are mainly:

- The introduction of cleaner engine technologies and limit values (NRMM stage IIIB) into the European vehicle fleet
- A smaller diesel locomotive fleet (UIC statistics indicate that a high share of diesel locomotives in Europe is not in active service any more) and lower mileages of old vehicles with old engines
- More efficient operation of diesel locomotives and diesel multiple units (DMU)
- Further electrification of railway lines (e.g. EU TEN-T corridors).

The Sustainability & Integration sub-project is in charge of developing a methodology for cost/benefit analysis and the calculation of life cycle costs of NRMM stage IIIB compliant rail vehicles as core elements to assess how the introduction of clean diesel technologies for rail impacts the overall emission performance of the European rail diesel fleet. Optimisation potentials of technical solutions and possible trade-offs have also been studied and analysed.

The CleanER-D Sustainability Study has identified the framework conditions and major influencing factors for the future development of the European rail diesel vehicle fleet and related exhaust emissions. Using the UIC UNIFE Rail Diesel Study from 2006 as a starting point, CleanER-D fleet data have been improved with information coming from more recent studies and results from a CleanER-D questionnaire survey conducted in 2011 among the main European operators of rail diesel vehicles. The upgrade of the dataset includes the topic of replacement engines as well as the average mileage per vehicle type, power class and age/emission class.

The CleanER-D fleet scenarios developed in the sub-project assume a further decline in the number of diesel locomotives which has also been observed in the years before 2008 and is expected to continue until 2020. In the same period, the number of DMUs will moderately increase due to high passenger transport demand. The developed fleet scenarios demonstrate that the migration of new exhaust emission reduction technologies into the fleet is comparably slow due to low numbers of new tendered and purchased diesel vehicles. The share of stage IIIA and IIIB locomotives in 2020 is estimated to be around 20 to 25% and the share of DMUs compliant to stage IIIA and IIIB about 35 to 40%.

The projected fleet development and related diesel exhaust emissions suggest that strategies to quickly migrate new technologies into the fleet will further substantially reduce emissions and thus maximise societal and especially environmental benefits. Therefore, market conditions have to be created which will increase the fleet and engine renewal rates.

The study also provides an overview of existing international legislation and the comparison of specific emissions of rail compared to other modes of transport. Currently, it can be concluded that the most stringent emission limits for rail applications are applied in Europe.

The current work of the Sustainability Impact Assessment investigates the societal benefit of the introduction of NRMM stages IIIA and IIIB in terms of avoided external (or damage) costs from the decreasing total exhaust emissions until 2020. Intermediary results indicate that the cumulated avoided external costs in 2020 sum up to several hundred million Euros. At the same time, life cycle cost assessment of NRMM stage IIIB engines will deliver expected LCC until 2020. Based on the Sustainability Impact Assessment, the Sustainability & Integration sub-project will develop sector-wide agreed recommendations on future emission reduction approaches and strategies of rail diesel traction in Europe, in order to further reduce emissions in the future.

From a technology point of view, the CleanER-D project focuses on existing and potential emission reduction technologies for integration into rail diesel vehicles and power packs as well as on the usage of energy storage systems for rail diesel applications.

The work so far has identified the state-of-the-art in after-treatment technologies for rail and automotive applications in particular, which will be used at a later stage to assess the most promising solutions. A specific task was dedicated to evaluate diesel particle filter (DPF) strategies and to assess emerging after-treatment technologies using stage IIIB emissions levels as a baseline, but also researching the suitability of these solutions beyond IIIB.

The potential use of alternative fuels has been investigated and the influence of fuel types on quality and emissions analysed. Detailed information and current state-of-the-art on biodiesel and alternative fuels have been collected and assessed. It can be concluded that generally, admixture including bio fuel up to 20% is acceptable. The potential use of alternative fuels lies on fuels obtained using the Fischer-Tropsch synthesis process (FT fuels). Among the issues highlighted by this work there is currently a clear trade-off between reducing carbon-based emissions and an increase in NO_x as well as fuel consumption. However, in-engine and after-treatment technology advances might be able to address this issue by the time these fuels are ready for uptake.

For the analysis of future after-treatment technologies, a 560 kW engine model for railcar applications has been developed. In addition, simulation tools have been used to design and analyse the performance of the engine plus exhaust gas recirculation system (EGR) and of the DPF and Selective Catalytic Reduction (SCR) devices. Within the consortium, the following technology combinations have been considered for future evaluation:

- Scenario 1: EGR plus DPF or SCR
- Scenario 2: EGR combined with DPF and SCR.

Emissions performance was evaluated over the C1 homologation cycle and in the case of the DPF over an approximated railcar driving cycle as well. Several BSNOx targets have been considered, namely: 2 g/kWh (Stage IIIB), 1 g/kWh and 0.4 g/kWh. The simulation activities also supported the consortium in generating primary data regarding space, weight and cooling requirements. In addition, a study of the influence of using the above mentioned technologies on the integration with the vehicles has been carried out. This activity will complete the assessment of technology innovations for future measures beyond IIIB on diesel railway applications.

The hybrid system is one of the most promising environmentally-friendly solutions of diesel applications. Hybrid applications can achieve a reduction of energy consumption while significantly cutting emissions. However, today, the use of energy storage solutions on diesel-trains is not state-of-the-art.

To better understand the characteristics of such systems, the CleanER-D project investigates energy storage technologies of Hybrid-Drive-Systems in combination with Diesel-Engines for rail application and their influence on reduction of fuel consumption and emissions.

The benefit of installing energy storage systems in diesel vehicles is to reuse braking energy, which is normally dissipated into heat by the braking resistor, and to provide more freedom in the overall design of the whole traction system due to the reduction of peak power which is normally requested from the diesel.

Preliminary results show that batteries and double-layer capacitors have the greatest potential amongst the investigated technologies. Both solutions are already available for lightweight vehicles in the railway sector. But the final recommendations for further reduction of fuel consumption and emissions using innovative hybrid technologies and energy storage devices will be delivered at the end of the project.

Finally, the project has also derived promising results with regard to fuel savings. We can conclude that the main potential of hybridisation can be achieved on suburban and regional trains due to frequent charging and discharging. With realistic boundary conditions in operation, a fuel saving potential of between 10 and 20% contention can be achieved.

There is still one year of work ahead towards the finalisation of CleanER-D. What we want to achieve in our research project is to provide reliable diesel applications for the railway sector and recommendations on future emission reduction solutions which maximise the environmental benefit for society with the lowest and most reasonable cost for the railway sector.

Reference

1. European Union emission inventory report 1990-2008 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

Diary dates:

- **Sustainability Seminar**
  Turin, 5 June 2013
- **CleanER-D Final Conference**
  Brussels, 20 November 2013

Judit Sandor has been Sustainability and Environment Manager at UNIFE since 2006. She is in charge of coordinating the UNIFE Sustainable Transport Committee and other environmental expert groups and following up research projects related to environment. She is the Project Coordinator of two EU funded R&D projects; CleanER-D and OSIRIS. Judit graduated from the Budapest University of Technology and Economics in 2005.

Roberto Palacin is a Senior Researcher and Head of the Rail Systems Group at NewRail, the Centre for Railway Research at Newcastle University. Roberto has a background in mechanical engineering, design and rail systems engineering. Over the past 15 years, Roberto has been involved in a number of collaborative research initiatives on subjects related to innovation in transport systems, vehicle and station design, design-led passenger environments, intermodality of the European rail network, development of modular concepts for high-speed and technology foresight.

Christian Kamburow graduated as a mechanical and electrical engineer and has been working at the IZT (Institute for Futures Studies and Technology Assessment) in Berlin since 2003 in the field of sustainable transport and energy. Christian has focused his research activities on environmental issues of railway transport such as energy efficiency, exhaust emissions, sustainable procurement and climate change adaptation and participated in or lead numerous research projects on these topics.

Henning Schwarz has been Senior Consultant for Environment and Sustainability at the Deutsche Bahn Environment Centre since 2011. He is leading the sub-project 'Sustainability & Integration' of the CleanER-D project. Henning was previously Head of the Sustainable Development Unit at the International Union of Railways (UIC). Henning graduated with a master's degree (Dipl.-Ing.) in Environmental Engineering from the Technische Universität of Berlin in 1999.

Michael Meinert graduated in Electrical Railway Systems from Dresden University of Technology, Germany in 1995 and received his doctorate in electrical engineering from Darmstadt University of Technology, Germany in 2007. His employment experience has been with Siemens AG in the field of Rolling Stock and Railway Power Supply as well as at the Darmstadt University of Technology from 2001 to 2004. Michael is currently the Head of the R&D Group for energy storage units/systems as well as overhead contact line free systems at the Siemens AG Infrastructure & Cities Sector.

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