

Impact on costs and emissions of technical measures on existing heavy duty vehicles and captive fleets

Preliminary findings

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Technical Measures - Methodology

- Review information through questionnaire sent to stakeholders and literature survey
- Summarise all the findings in a format that can be directly analysed by the model TREMOVE for:
 - the analysis of the cost-effectiveness of scenarios
 - the analysis of the impact on pollutant emissions.
- Feed information into policy review

TREMOVE model

- TREMOVE is a policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector.
- For each year, the TREMOVE produces figures on the vehicle-kilometres and vehicle speeds for road transport disaggregated according to:
 - Vehicle type
 - Fuel type
 - Vehicle technology
 - Vehicle age (age and technology are related to each other)
 - Network (urban road, non-urban road, motorway)
 - Region (metropolitan, other cities, non-urban)
 - Period of day
- For each of this disaggregated vehicle-km, TREMOVE calculates the emissions (NO_x, CO₂, VOC, PM₁₀ etc.)

TREMOVE scenario analysis

- A scenario run needs a lot of work for definition, data input and calculation. To reduce number of scenarios it is proposed to:
 - Select the most effective and cost efficient technologies
 - Define combinations of technical measures to be implemented within the same scenario,
 - Define different degrees of penetration rates (e.g. maximum, optimistic, realistic, low penetration) of vehicle stock.
- Scenarios will be variation of the TREMOVE base case. Following information needed for each technical measure:
 - Impact on emissions and fuel consumption as correction factor related to the base technology of each vehicle category for the road categories “urban”, “non-urban” and “motorways” – or an averaged factor.
 - Costs (as cost difference from the base technology) for capital and operation costs
 - Penetration in the fleet as a share of each of the six heavy duty vehicle classes (Buses, Coaches, HDV<7.5T, 7.5-16T, 16-32T, >32T)

Review of Technical Measures – results to date

- Information gathered to determine:
 - What technologies are available
 - Reductions in regulated emissions (CO, NO_x, VOCs, PM₁₀), also Greenhouse Gas Emissions and most problematic non-regulated emissions such as PM in number, NO₂, N₂O
 - Capital and operational costs

Sources of information

- Detailed questionnaire
 - 24 responses reviewed
- Literature search of published information
 - >250 technical papers accessed and reviewed
- Reference to CARB, USEPA, BAFU/SUVA and VERT lists of certified measures.

Technical measures - categorisation

- **The technical measures reviewed have been categorised as follows:**
- *Primary measures*
 - most promising technical measures for reducing PM and NO_x
- *Secondary measures*
 - should be encouraged to be used in conjunction with primary measures.
 - should be further examined to explore their potential in a European context.
- *Other measures*
 - not close enough to market
 - no significant impact upon the emissions from existing heavy-duty vehicles
 - Not as cost effective as other
 - ***This does not mean that they are not valid technologies, particularly in terms of CO₂ emissions.***

Primary measures

- Exhaust emissions retro-fit measures
 - Diesel Oxidation Catalyst (DOC)
 - Diesel Particulate Filter (DPF)
 - Exhaust Gas Recirculation (EGR)
 - Selective Catalytic Reduction (SCR)
 - SCR+DPF
- Re-powering
- Alternative liquid fuels
 - Ethanol
 - Diesel Water Emulsion (DWE)
- Alternative gaseous fuels
 - Natural Gas (as diesel/CH₄ dual fuel)
 - Bio-methane (as diesel/CH₄ dual fuel)

Secondary measures

- Low Ash Lubricants
- Closed Crankcase Ventilation systems
- Measures to reduce impact of idle emissions – use of APUs, truck stop electrification

Other measures

- Exhaust emissions retro-fit measures
 - Lean NO_x Traps (LNT)
- Alternative liquid fuels
 - Dimethyl-ether (DME)
 - Fatty Acid Methyl Esters (FAME)
 - Synthetic Diesel (Fischer-Tropsch)
- Other measures
 - Fuel Additives (other than FBC)
 - Retro-fit hybrid drives
 - Low Viscosity Lubricants
 - Low Rolling Resistance Tyres

Primary measures – issues (1)

- Diesel Oxidation Catalyst (DOC)
 - Produces NO_2 , little impact on soot reduction, can increase PM through SO_4 formation, potentially high ultrafine emissions, may present corrosion issues
- Diesel Particulate Filter (DPF)
 - Some filters require cleaning, catalysed and continuously regenerating systems can increase NO_2 , small fuel consumption penalty
- Exhaust Gas Recirculation (EGR)
 - Potential slight reduction in performance and fuel economy and increased maintenance of engines. Potential risk of accelerated engine wear.
- Selective Catalytic Reduction (SCR)
 - Needs reductant, potential for N_2O formation, ineffective under “cool” operating cycles, little impact on soot reduction (although can be offset by calibration)
- SCR+DPF
 - As above but combination reduces soot by >90%

Primary measures – issues (2)

- Repowering
 - May not confer expected emissions benefits in real world conditions, expensive, niche market
- Ethanol
 - Lower energy density than diesel, good regulated emission performance but information required on particle number
- Diesel Water Emulsion (DWE)
 - Impact on emissions appears to be influenced by drive cycle and level of engine technology, potential warranty implications
- Natural Gas (as dual fuel)
 - Payload and packaging, expensive, potential for CH₄ emissions, ultrafine emissions could be similar to diesel, potentially poor resale value, fuel infrastructure
- Bio-methane (as dual fuel)
 - As above but potential to reduce GHG on WTW basis. Fuel availability

Secondary measures - issues

- Low Ash Lubricants
 - Cost information required to be factored into DPF operational costs
- Closed Crankcase Ventilation systems
 - Quantification of contribution to air quality and potential benefits in a European context needed
- Measures to reduce impact of idle emissions – use of APUs, truck stop electrification
 - Quantification of contribution to air quality and potential benefits in a European context needed

Other measures - issues

- Lean NO_x Traps (LNT)
 - early stages of development, difficulties with sulphur poisoning, very low sulphur fuel and lubricating oil requirements
- Dimethyl-ether (DME)
 - Good emissions but early stages of production and volume uncertainties
- Fatty Acid Methyl Esters (FAME)
 - low impact on PM and NO_x emissions
- Synthetic Diesel (Fischer-Tropsch)
 - early stages of production and volume availability, and therefore uncertainties
- Fuel additives (other than FBC)
 - low impact on PM and NO_x emissions
- Retro-fit hybrid drives
 - early stage of development, and therefore supply uncertainties
- Low viscosity lubricants
 - low impact on PM and NO_x emissions
- Low rolling resistance tyres
 - low impact on PM and NO_x emissions

Ranking of primary measures

- “Quick and Dirty” ranking exercise
- Non-weighted approach at this stage
- Each measure compared scored 1 – 19
 - 1 = worse, 19 = best, 10 = no impact
- Scored for NO_x, PM, NO₂, HC, CO, FC/CO₂, particle number, cost (capital/operational)
- HC/CO impact and cost removed

Non-weighted ranking of measures

| Measure | Overall ranking |
|-------------------------------------|-----------------|
| DPF (active regeneration) | 102 |
| SCR+DPF (active regeneration) | 102 |
| DPF (FBC) | 101 |
| DPF (CRT®, catalysed) | 99 |
| SCR+DPF(CRT®, catalysed) | 99 |
| DOC | 93 |
| Dual fuel diesel/natural gas/biogas | 87 |
| DPF (partial flow) | 85 |
| SCR | 81 |
| Ethanol | 79 |
| DWE | 77 |
| Repower to Euro 4 | 76 |
| EGR | 70 |

Non-weighted ranking of measures - excluding cost, HC, CO benefits

| Measure | Overall ranking |
|-------------------------------------|-----------------|
| SCR+DPF (active regeneration) | 70 |
| DPF (active regeneration) | 68 |
| DPF (FBC) | 68 |
| SCR+DPF(CRT®, catalysed) | 65 |
| DPF (CRT®, catalysed) | 63 |
| SCR | 59 |
| Dual fuel diesel/natural gas/biogas | 58 |
| Repower to Euro 4 | 56 |
| DWE | 53 |
| Ethanol | 51 |
| DPF (partial flow) | 49 |
| EGR | 48 |
| DOC | 46 |

Non-weighted ranking of measures - excluding, HC, CO benefits

| Measure | Overall ranking |
|-------------------------------------|-----------------|
| SCR+DPF (active regeneration) | 86 |
| DPF (active regeneration) | 86 |
| DPF (FBC) | 83 |
| SCR+DPF(CRT®, catalysed) | 81 |
| DPF (CRT®, catalysed) | 81 |
| DOC | 79 |
| DWE | 72 |
| SCR | 71 |
| Dual fuel diesel/natural gas/biogas | 69 |
| DPF (partial flow) | 67 |
| Repower to Euro 4 | 65 |
| Ethanol | 64 |
| EGR | 60 |

Penetration scenarios

| Vehicle category | Low penetration | Realistic | Optimistic | Maximum |
|------------------|-----------------|-----------|------------|---------|
| Bus | | | | |
| Coach | | | | |
| HDV <7.5T | | | | |
| HDV 7.5-16T | | | | |
| HDV 16-32T | | | | |
| HDV >32T | | | | |

Questions

- Are there any serious errors in the data?
- Have we got the categories correct?
- Are the measures in the right categories?
- Are there any measures we have not considered?
- Do you broadly agree with the relative ranking of the measures?
- Can you provide data for penetration scenarios?

Further comments to
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preferably by 15th September

papers available on website