Cost curves for HDVs

Establishing marginal abatement cost curves for Heavy Duty Vehicles for packages of technical measures

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Overview presentation

- Objective of the project
- Scope of the project
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Objective of the project

- Derive marginal abatement cost (MAC) curves, at the vehicle level, for packages of technical CO_2 reduction options for HDVs

- Since MAC curves depends heavily on parameter/variable values applied, the MACH model has been developed which provides users the opportunity to adjust the values of some of the parameters/variables themselves.

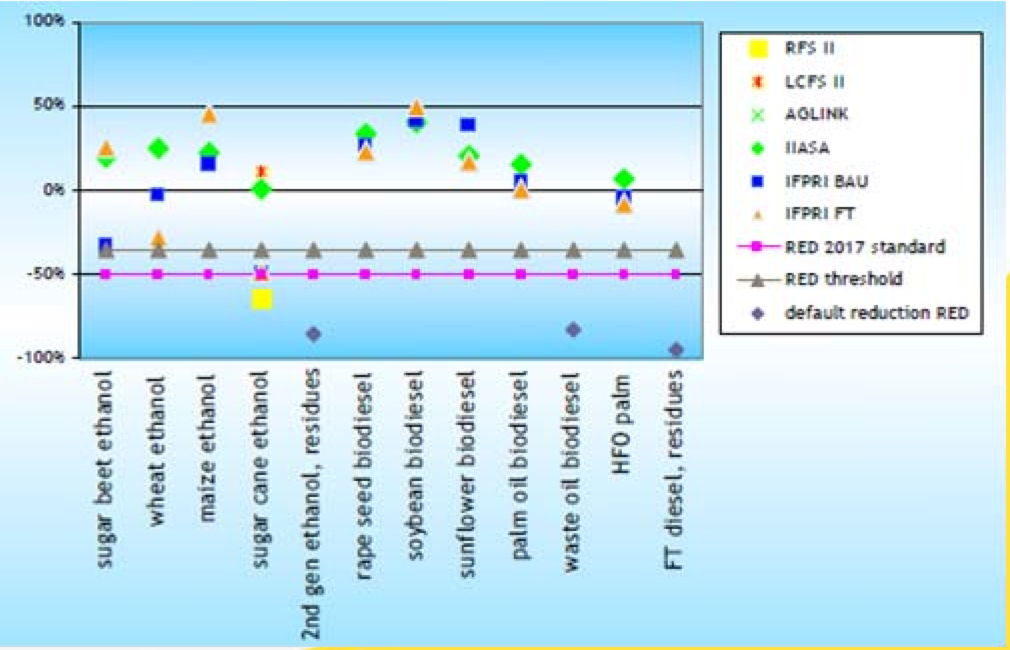
Scope of the project (1)

- MAC curves are derived for the following vehicle categories:
  - Service/delivery (< 7.5 ton)
  - Urban delivery/collection
  - Municipal utility
  - Regional delivery/collection
  - Long haul
  - Construction
  - Bus
  - Coach

- Additionally ‘average’ MAC curves for trucks and busses are developed

Scope of the project (2)

- Only technical CO_2 reduction measures are considered
- Biofuels are not taken into account since:
  - Taking ILUC effects into account many biofuels may not result in an reduction of GHG emissions
  - Biofuels actually reducing GHG emissions are expensive and hence will show up at the right side of the cost curve.



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Methodology

- Methodology consists of three steps:
  1. Estimate cost effectiveness of all individual abatement technologies
     - Based on total costs and benefits over lifetime technology
     - Cost effectiveness $= \frac{I - NPV\ (\Delta lifetime\ fuel\ costs)}{Lifetime\ CO2\ emission\ reduction}$
  2. Rank all abatement technologies based on their cost effectiveness
  3. Estimate combined reduction potential of abatement technologies
     - Combined reduction potential (%) =

$$100 \times (1 - (1 - \frac{RP1}{100}) \times \left(1 - \frac{RP2}{100}\right) \times \ \dots \times (1 - \frac{RPi}{100}))$$

- Average MAC curves:
  - In general same approach
  - But abatement potentials are weighted by shares in total CO_2 emissions of trucks and busses

Input values: methodology

- Desk research to establish a set of input data

- Two key studies on abatement technologies for HDVs
  - TIAX (2011) – *European Union Greenhouse Gas reduction Potential for Heavy-Duty Vehicles*
  - AEA/Ricardo (2011) – *Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles*

- Attempt to explain the main differences between both studies:
  - Thorough review of both reports
  - Interviews with authors of these studies
  - Comparison to other studies on abatement technologies for HDVs

Input values: baseline

- Baseline vehicles
  - TIAX (2011): 2014 vehicles meeting Euro VI emission standards

- Other baseline assumptions

Vehicle segment	Vehicle lifetime	Annual mileage (kilometres)	Fuel consumption (l/100 km)
Service/delivery	10	35.000	16.0
Urban delivery/collection	19	40.000	21.0
Municipal utility	17	25.000	55.2
Regional delivery/collection	12	60.000	25.3
Long haul	8	130.000	30.6
Construction	19	50.000	26.8
Bus	14	50.000	36.0
Coach	12	52.000	27.7

Input values: technical measures

- Set of technical measures included the same as in TIAX (2011)
  - Aerodynamics
  - Lightweighting
  - Tires and wheels
  - Transmission and driveline
  - Engine efficiency
  - Hybridisation
  - Management

- Abatement potential based on TIAX (2011):
  - Depends heavily on baseline vehicles
  - Differences in abatement potential between TIAX and AEA/Ricardo are mainly due to differences in baseline vehicles. Remaining differences are rather small.

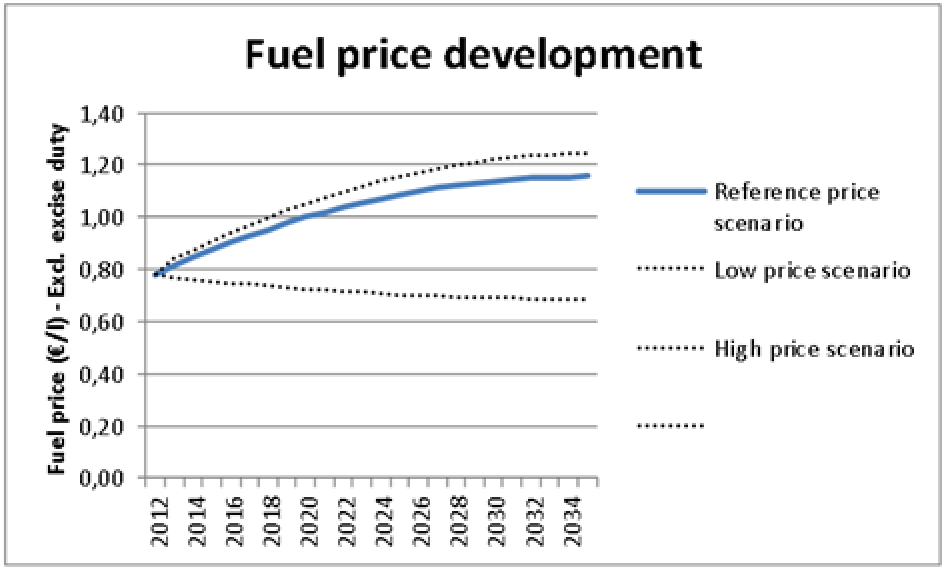
Input values: investment costs

- Investment costs: significant differences between TIAX and AEA/Ricardo due to:
  - Differences in baseline vehicles
  - Differences in specifications of technical measures
  - Differences due to uncertainties in cost estimates
    - Many of the AEA/Ricardo estimates fall within ranges defined by TIAX/NAS (2009)

- Input values for the model
  - Default values are based on TIAX (2011)
  - Ranges based on TIAX/NAS (2009) for most technologies
  - For some technologies upper/lower bounds are based on AEA/Ricardo (2011) or other studies

MACH model

- Marginal Abatement Cost curves for Heavy duty vehicles (MACH) model
- In the model the following parameters/variables could be adjusted to carry out sensitivity analyses:
  - Perspective applied: social and end-user perspective
  - Discount rate: ranges between 2-7% (social perspective) and 4-12% (end-user perspective)
  - Fuel prices: three scenarios and custom-made
  - Time horizon: between 3 years and vehicle's lifetime
  - Investment costs: ranges based on literature review



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Output trucks (1)

Break-even abatement potential urban delivery trucks

	Time horizon: 3 years	Time horizon: measure's lifetime
Social perspective		
Low fuel price scenario	3%	44%
Reference fuel price scenario	5%	44%
High fuel price scenario	5%	44%
End-user perspective		
Low fuel price scenario	10%	44%
Reference fuel price scenario	10%	44%
High fuel price scenario	20%	44%

Output trucks (2)

Break-even abatement potential long haul trucks

	Time horizon: 3 years	Time horizon: measure’s lifetime
Social perspective		
Low fuel price scenario	33%	36%
Reference fuel price scenario	33%	36%
High fuel price scenario	33%	36%
End-user perspective		
Low fuel price scenario	33%	36%
Reference fuel price scenario	33%	36%
High fuel price scenario	33%	36%

Output trucks (3)

Break-even abatement potential trucks (average)

	Time horizon: 3 years	Time horizon: measure's lifetime
Social perspective		
Low fuel price scenario	20%	32%
Reference fuel price scenario	20%	33%
High fuel price scenario	20%	33%
End-user perspective		
Low fuel price scenario	24%	34%
Reference fuel price scenario	24%	34%
High fuel price scenario	24%	34%

Output trucks: impact of discount rate

Break-even abatement potential for different discount rates
(social perspective, long time horizon, reference fuel price)

Category	Discount rate: 2%	Discount rate: 4%	Discount rate: 7%
Service	13%	13%	13%
Urban delivery	44%	44%	44%
Municipal utility	36%	36%	17%
Regional delivery	33%	31%	31%
Long haul	36%	36%	36%
Construction	45%	45%	45%
Average	34%	33%	32%

Output busses (1)

Break-even abatement potential busses

	Time horizon: 3 years	Time horizon: measure's lifetime
Social perspective		
Low fuel price scenario	13%	43%
Reference fuel price scenario	13%	43%
High fuel price scenario	13%	43%
End-user perspective		
Low fuel price scenario	13%	43%
Reference fuel price scenario	43%	43%
High fuel price scenario	43%	43%

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Output busses (2)

Break-even abatement potential coaches

	Time horizon: 3 years	Time horizon: measure's lifetime
Social perspective		
Low fuel price scenario	4%	25%
Reference fuel price scenario	4%	25%
High fuel price scenario	4%	25%
End-user perspective		
Low fuel price scenario	10%	25%
Reference fuel price scenario	10%	25%
High fuel price scenario	10%	25%

Output busses (3)

Break-even abatement potential busses (average)

	Time horizon: 3 years	Time horizon: measure's lifetime
Social perspective		
Low fuel price scenario	9%	36%
Reference fuel price scenario	9%	36%
High fuel price scenario	9%	36%
End-user perspective		
Low fuel price scenario	12%	36%
Reference fuel price scenario	30%	36%
High fuel price scenario	30%	36%

Output busses: impact of discount rate

Break-even abatement potential for different discount rates
(social perspective, long time horizon, reference fuel price)

Category	Discount rate: 2%	Discount rate: 4%	Discount rate: 7%
Bus	43	43	43
Coach	25	25	25
Average	36	36	36

Conclusions

- Both for trucks and busses a significant CO_2 abatement potential with zero or negative costs is available.
  - Trucks: ca. 33%
  - Busses: ca. 36%

- Significant differences between vehicle categories:
  - E.g. Service ca. 13% vs. Construction ca. 45%

- Results are rather robust, particularly with respect to the average curves
  - Impact of parameters like discount rate, perspective of the analysis, fuel price is limited