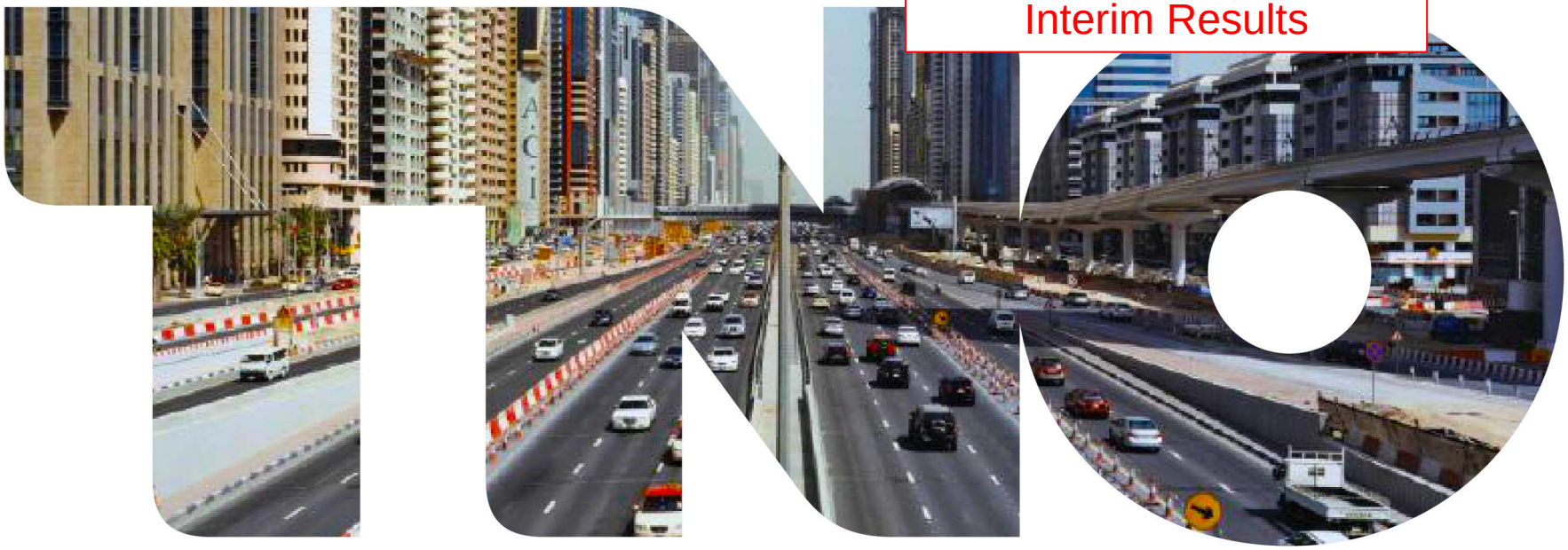
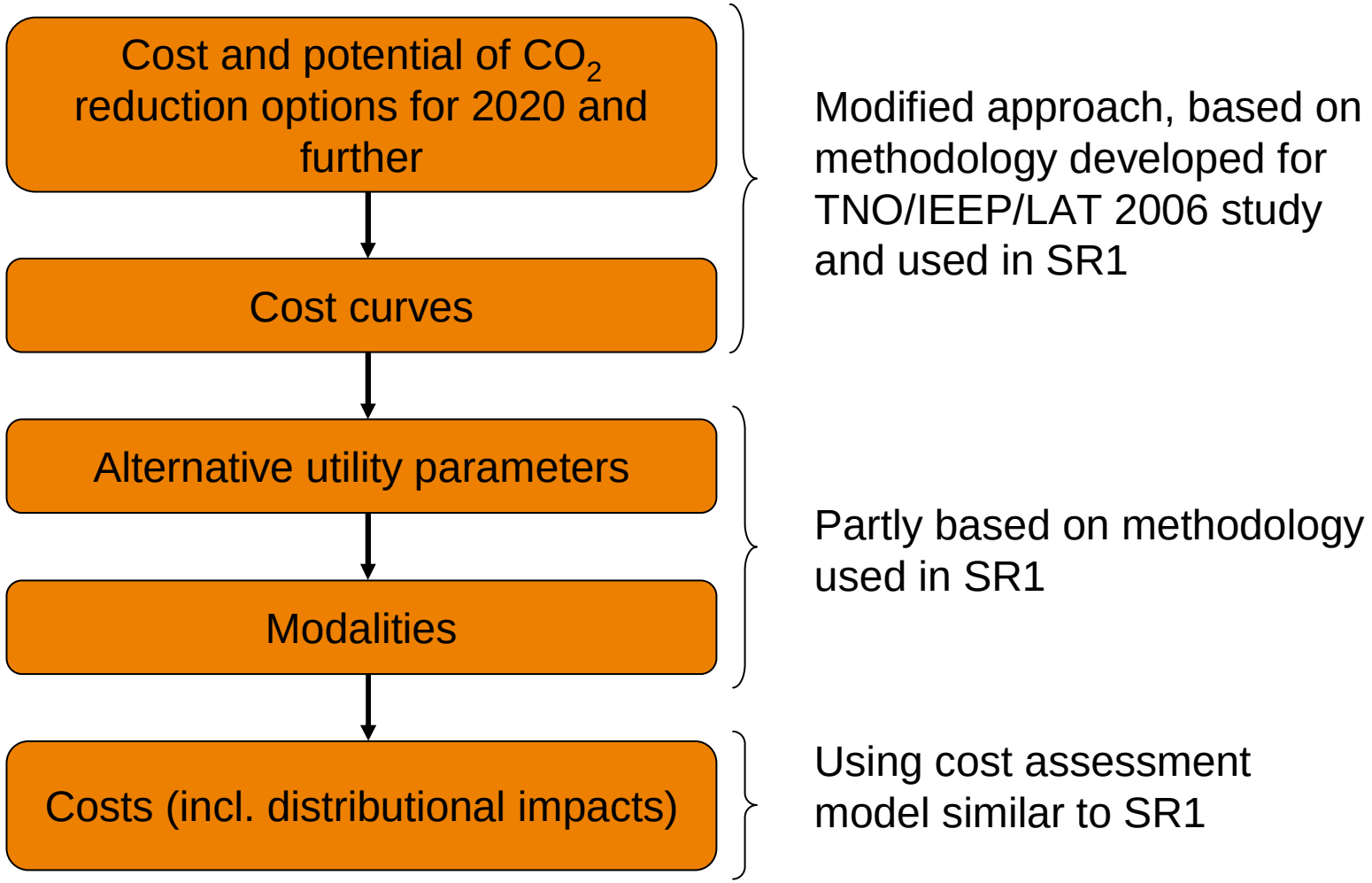
Support for the revision of regulation on CO_2 emissions from light commercial vehicles

Service request #3
for Framework Contract on Vehicle Emissions - No ENV.C.3./FRA/2009/0043
Maarten Verbeek, Richard Smokers

Work in progress
Interim Results



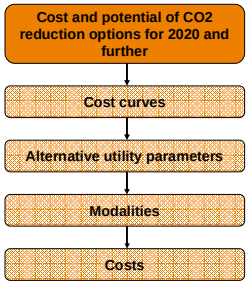
The process from CO_2 reduction options to costs for meeting the target



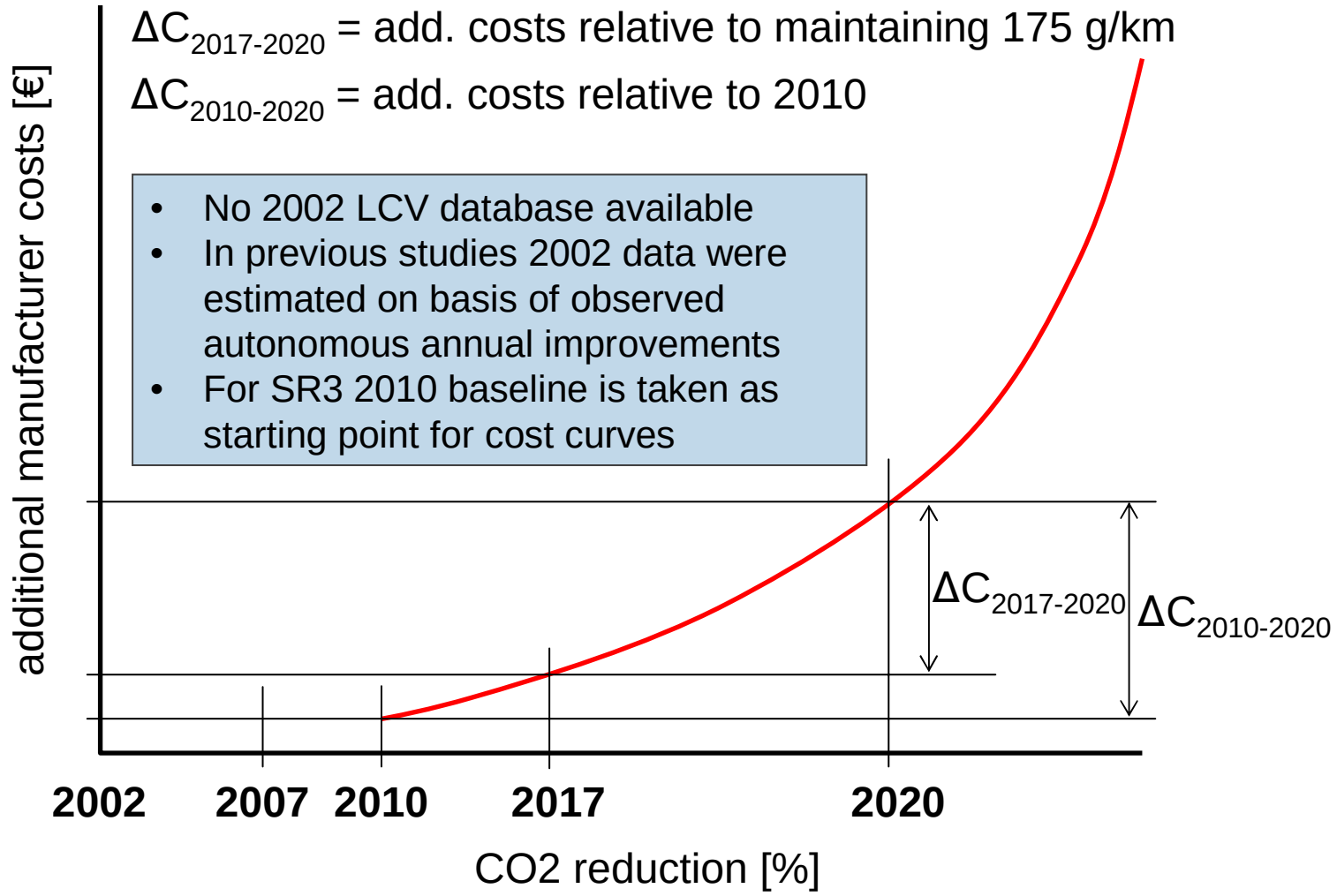
Cost and potential of CO_2 reduction options for 2020 and further

- Draft list of candidate CO_2 reduction options
- Information obtained from:
  - **Literature** review
  - **In-house database** and consultation of **in-house experts**

- For LCVs **different baseline** was chosen
  - Difference in methodology compared to SR1 and previous LCV work
  - All costs and reduction potentials relative to **2010 baseline vehicles**



Cost and potential of CO_2 reduction options for 2020 and further



Cost and potential of CO2 reduction options for 2020 and further
Cost curves
Alternative utility parameters
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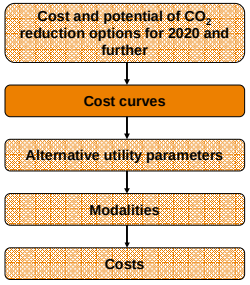
Cost curves construction methodology

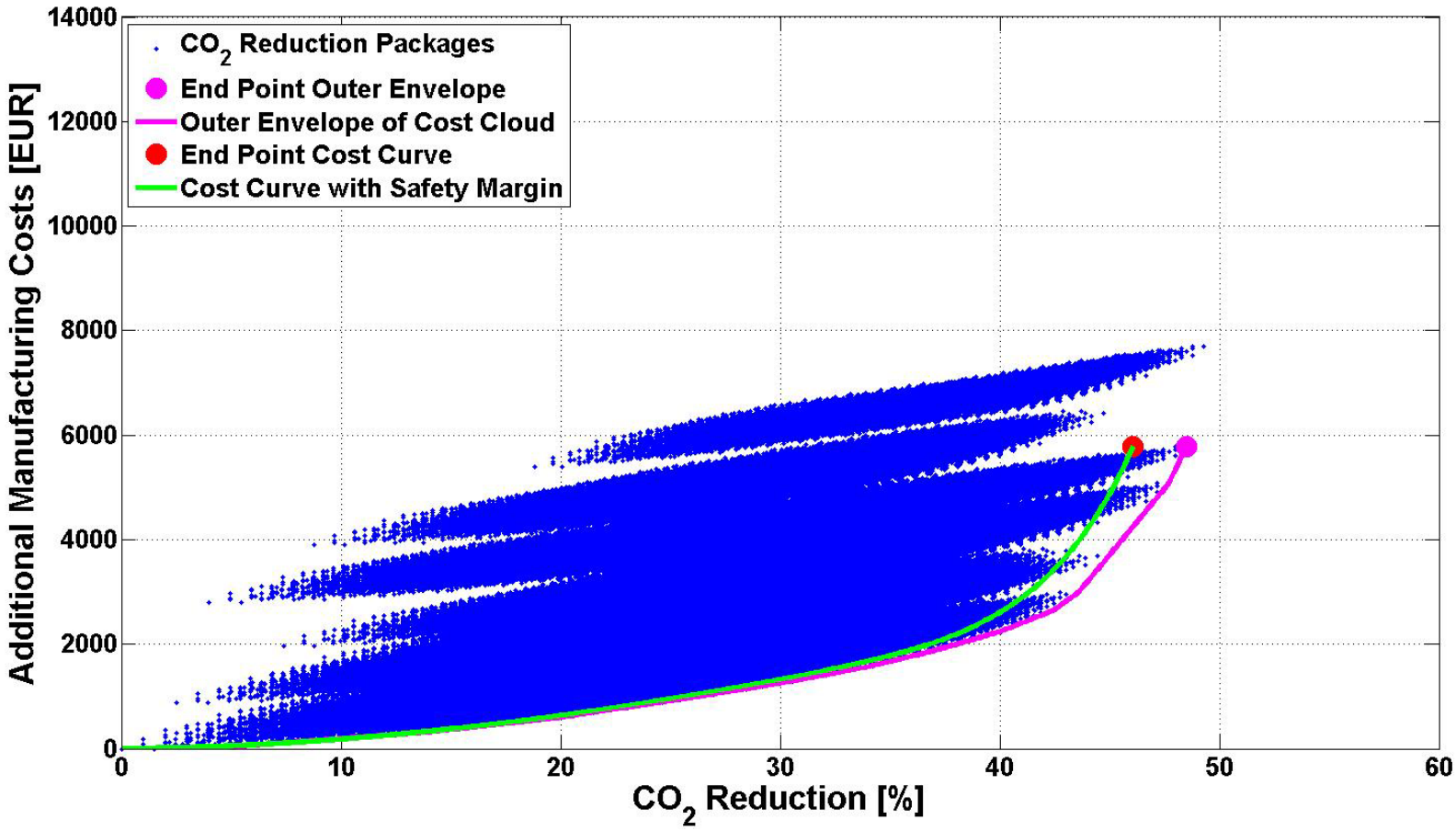
- Segmentation into **small (Class I)**, **medium (Class II)** and **large (Class III)**
- Only **diesel** (96% of new registrations in 2010)
- Definition of **packages** of CO_2 reduction options

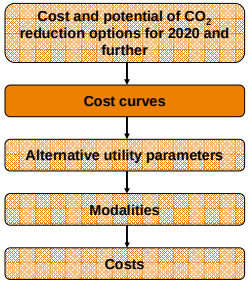
$$E_{package} = E_{baseline} \times \prod_{i=1}^{n} (1 - \delta_i)$$

- The **cost curve** is shaped to follow the curvature of the 'cloud' with a "safety margin" increasing to 5% at the end point. The margins are based on:
  - Previous work conducted within the consortium
  - Expert judgement of the dis-synergy between various technologies

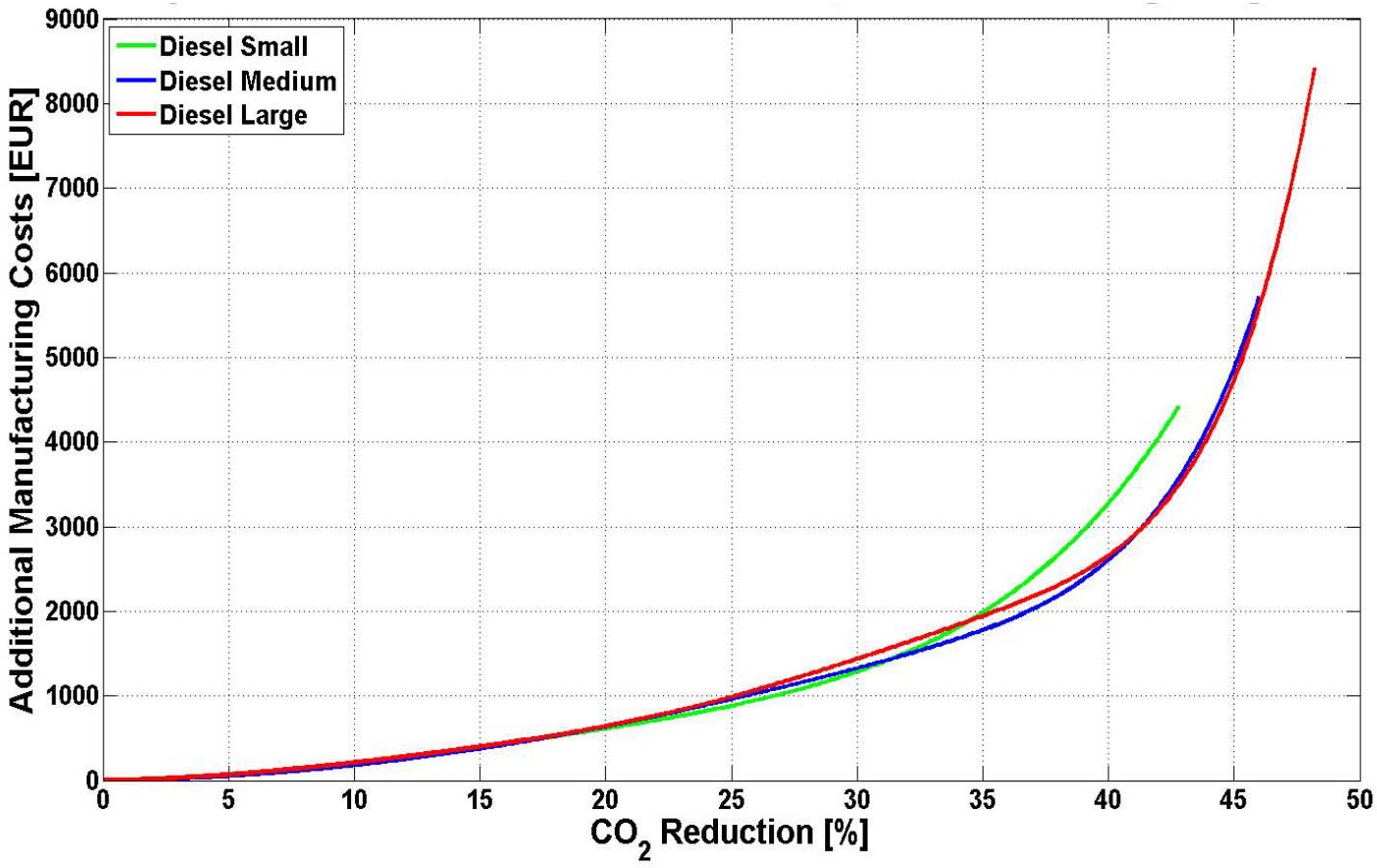


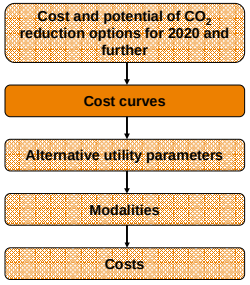
Cost curve example for Class II Diesel





Comparison of cost curves for LCV segments Small, Medium and Large

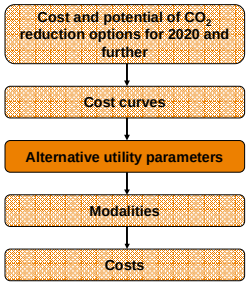




Note: In previous 2009 LCV impact study for 175 gCO_2/km. cost curves were defined as function of absolute ΔCO_2

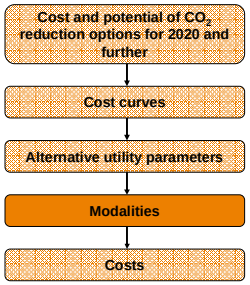
Sales database analysis on alternative utility parameters

Utility parameter	Advantages	Disadvantages
Reference mass	• Easily / objectively measured • Accepted by industry (continuity with current legislation) • Good correlation with CO_2	• Makes weight reduction as CO_2 reduction measure less attractive (partly compensated by Payload advantage) • Options for gaming (partly compensated by Payload advantage) • Not a measure of utility
Footprint	• Easily / objectively measured • Good proxy for utility • Used in US legislation	• Moderate correlation with CO_2 • Options for gaming, especially as the footprint levels off > $9m^2$
Payload	• Good proxy for utility	• Moderate correlation with CO_2 • Options for gaming, especially as the footprint levels off > 1000kg • Declared value

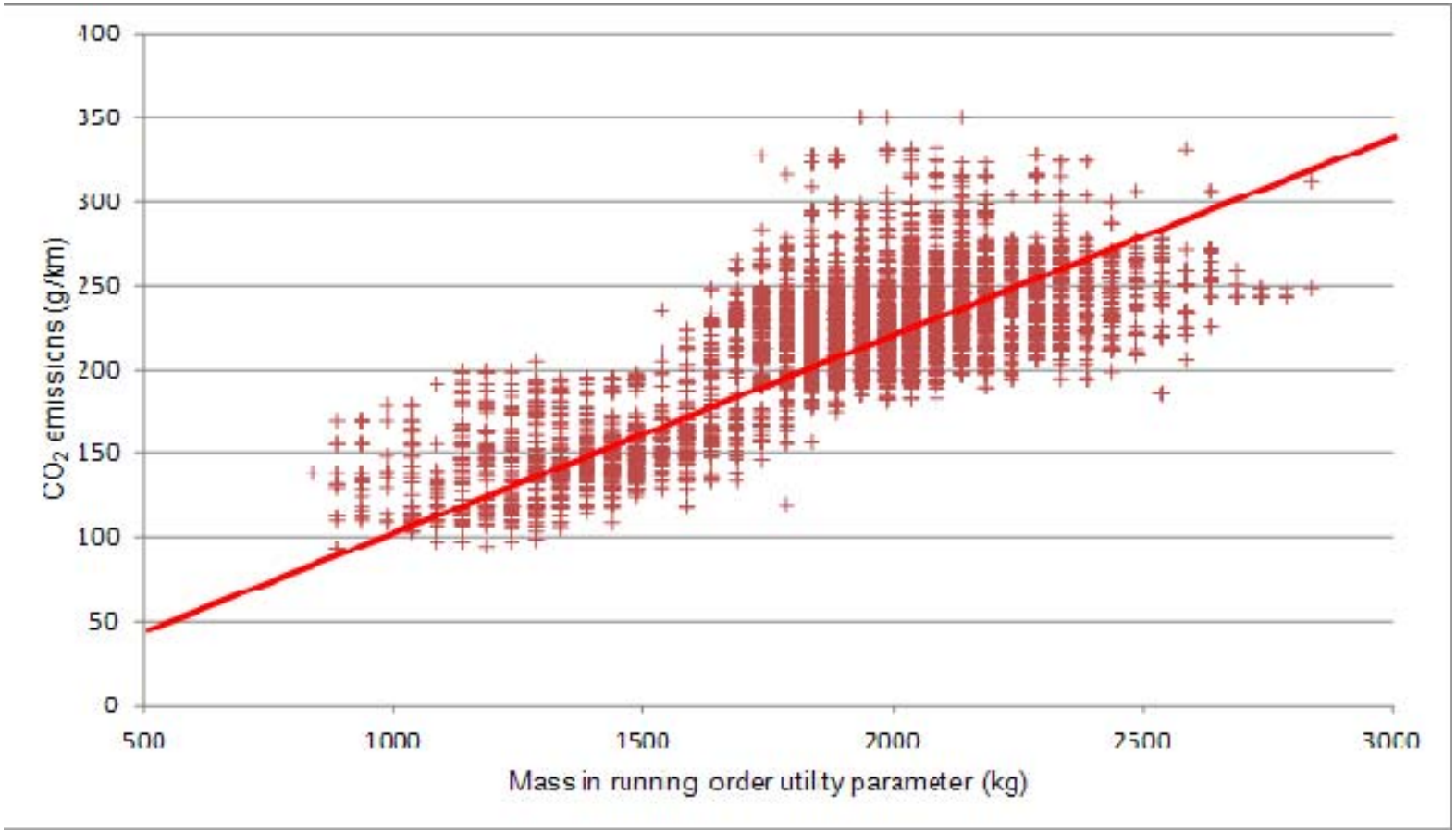


Modalities for 147g/km in 2020

- **Target Focus:** average CO_2 emissions of the total EU sales of manufacturer groups
- **Target Type:**
  - linear
    - 60% - 140% lines currently being assessed
- **Utility Parameter:**
  - Analysed utility parameters:
    - Reference mass
    - Footprint
    - Payload



CO_2 and reference mass and the sales weighted least squares fit



Cost and potential of CO_2 reduction options for 2020 and further
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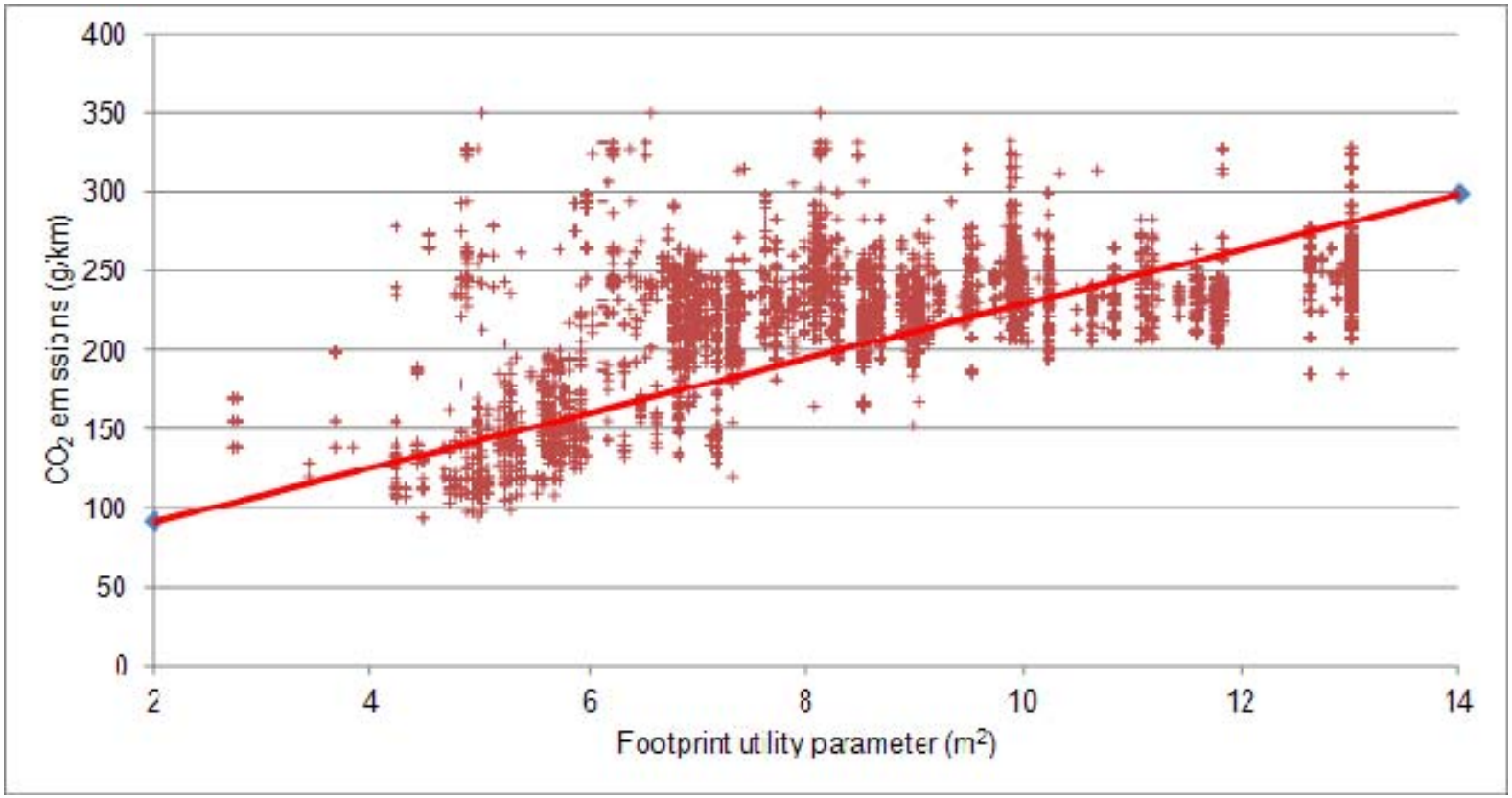
CO_2 and footprint and the sales weighted least squares fit



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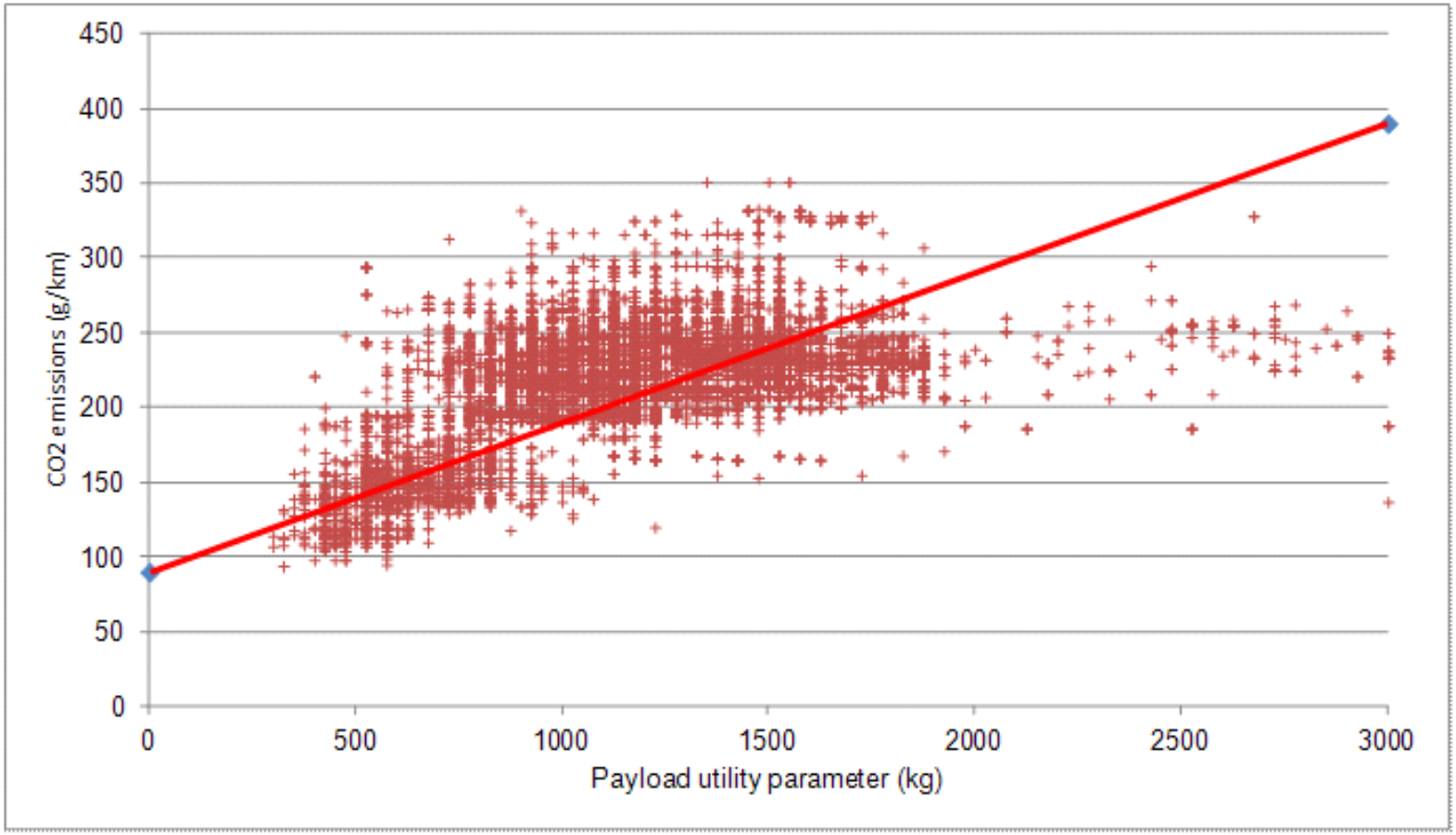
CO_2 and payload and the sales weighted least squares fit



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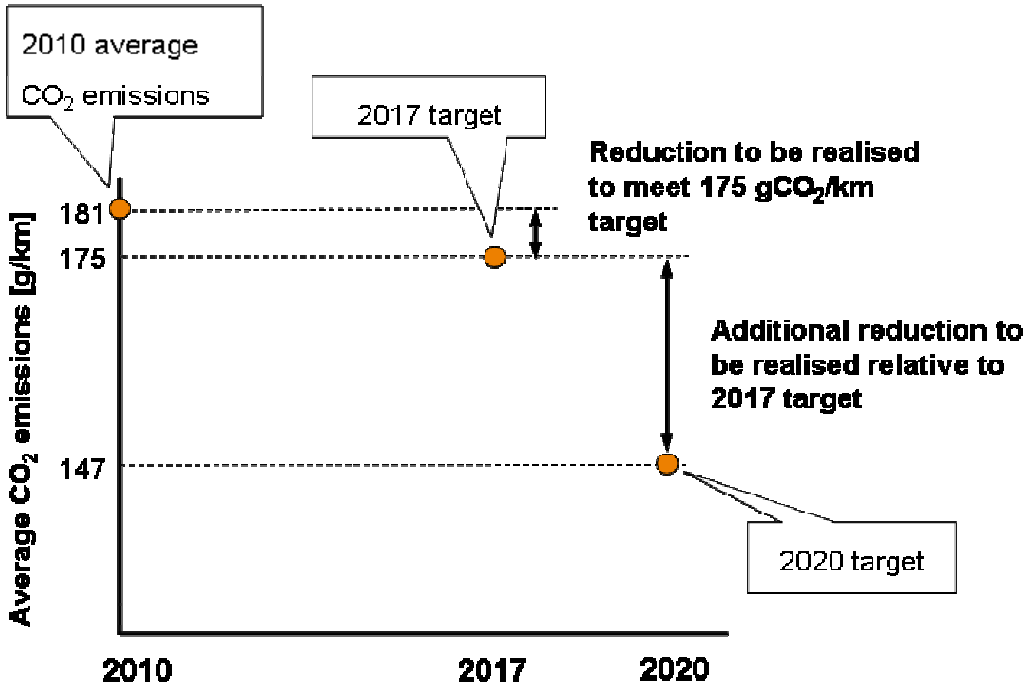
Additional costs calculation methodology



- "Manufacturer groups" resulted from assessing corporate brand ownership as of 01/10/2011
- Additional manufacturer costs are calculated by determining the **lowest cost distribution** of CO_2 reductions over the 3 segments (Class I, ClassII and ClassIII)
  - Optimisation of additional manufacturer costs

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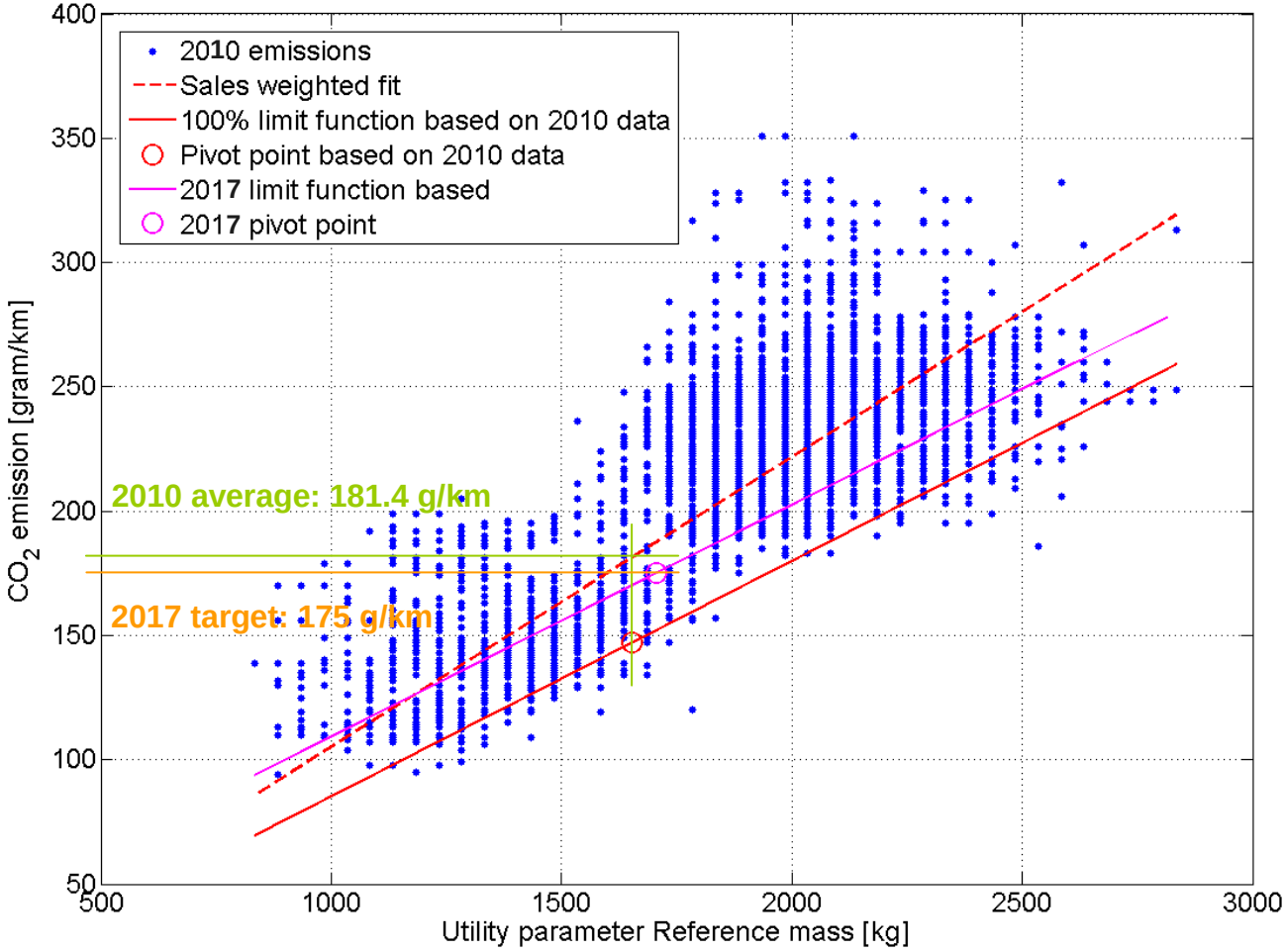
The 100% mass-based limit function based on 2010 data is slightly steeper than 2015 legislation



- Cost and potential of CO_2 reduction options for 2020 and further
- Cost curves
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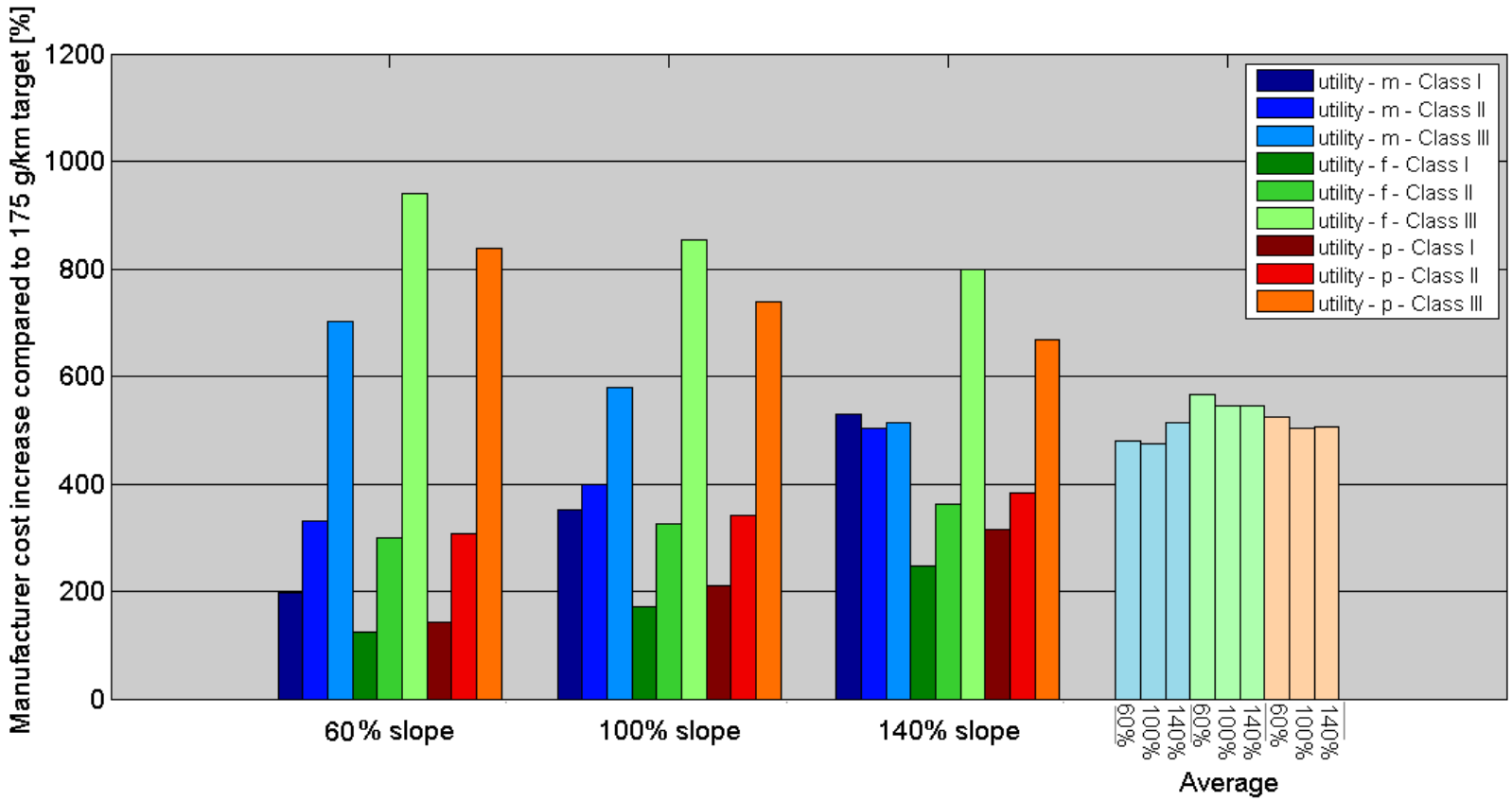
› 2010 average is already quite close to 2017 target

Manufacturer cost increase relative to 175 gCO_2/km



- Even distribution of burden only achieved for high slope values for Footprint and Payload. This offers room for gaming.
- **Conclusion**: Footprint and Payload are not preferable utility parameters

Cost and potential of CO_2 reduction options for 2020 and further
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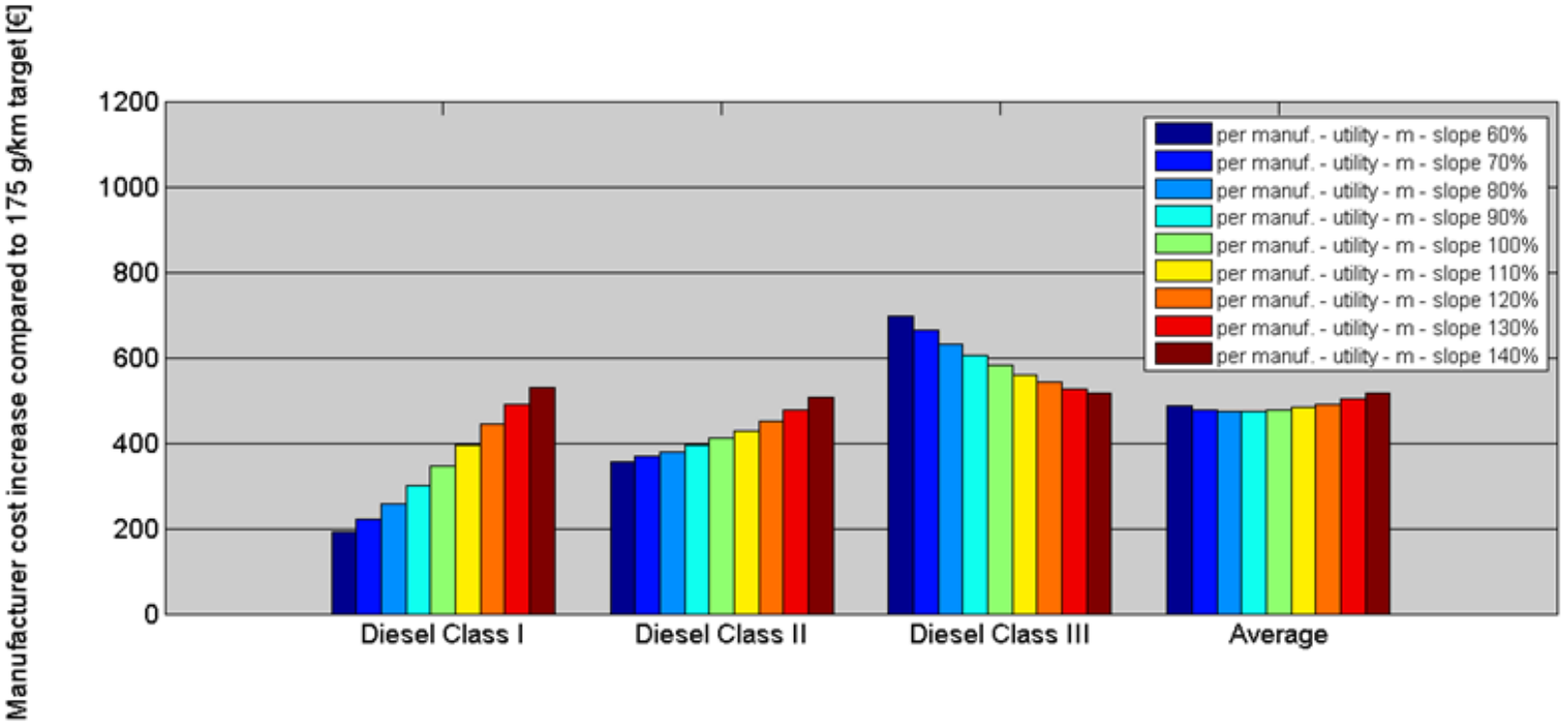
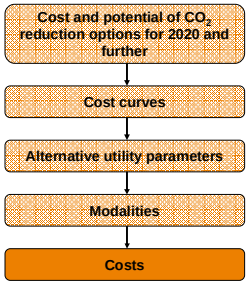
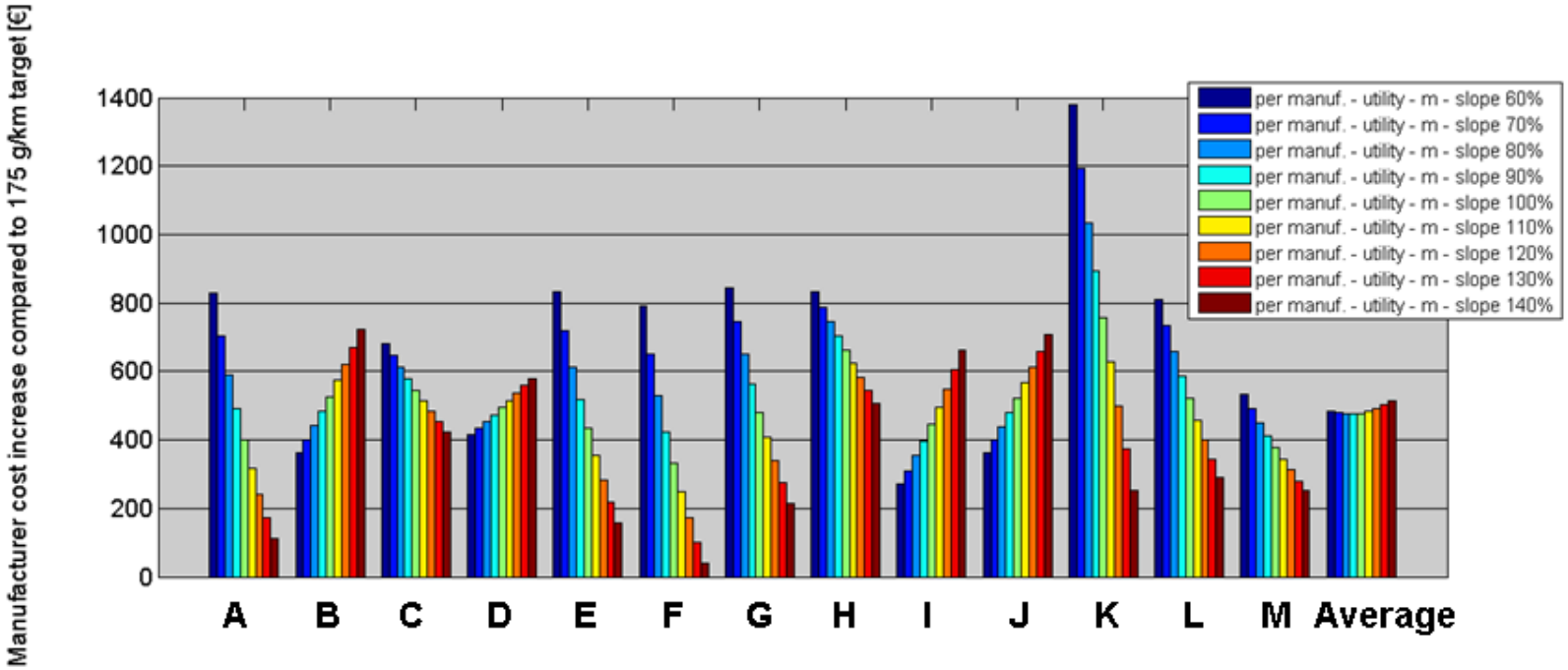
Average additional manufacturer costs are lowest close to 100% slope for a linear mass-based limit function





Slope has a relatively large impact on cost increase per manufacturer group because average mass of various manufacturers is relatively far from fleet average



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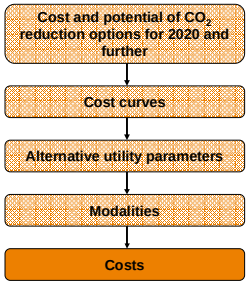
Conclusions

- Footprint and payload have relatively many disadvantages as utility parameter compared to reference mass:
  - Footprint and payload: relatively easy parameters for gaming
  - Payload: declared value
- The 147 gCO_2/km can be achieved by relatively low additional cost
  - ~ 500 €/vehicle relative to maintaining 175 g/km
  - equivalent to relative sales price increase of less than 3%
- Overall average costs are sensitive to the slope of the utility based limit function but the sensitivity is limited
  - Lowest average cost impact achieved for mass-based limit function with a slope close to 100%

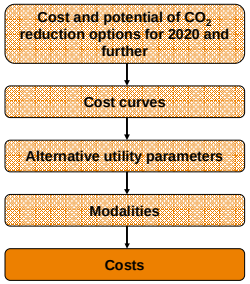


Conclusions

Feasibility of the 2020 target

- Based on
  - new LCV-specific cost information and
  - the fact that 2010 average is already quite close to the 2017 target

  the achievability of 2020 target of 147 g/km is found to be much better than estimated in previous studies

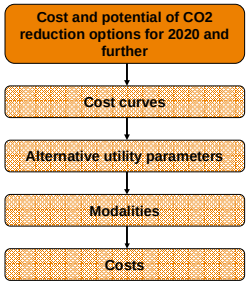


Questions

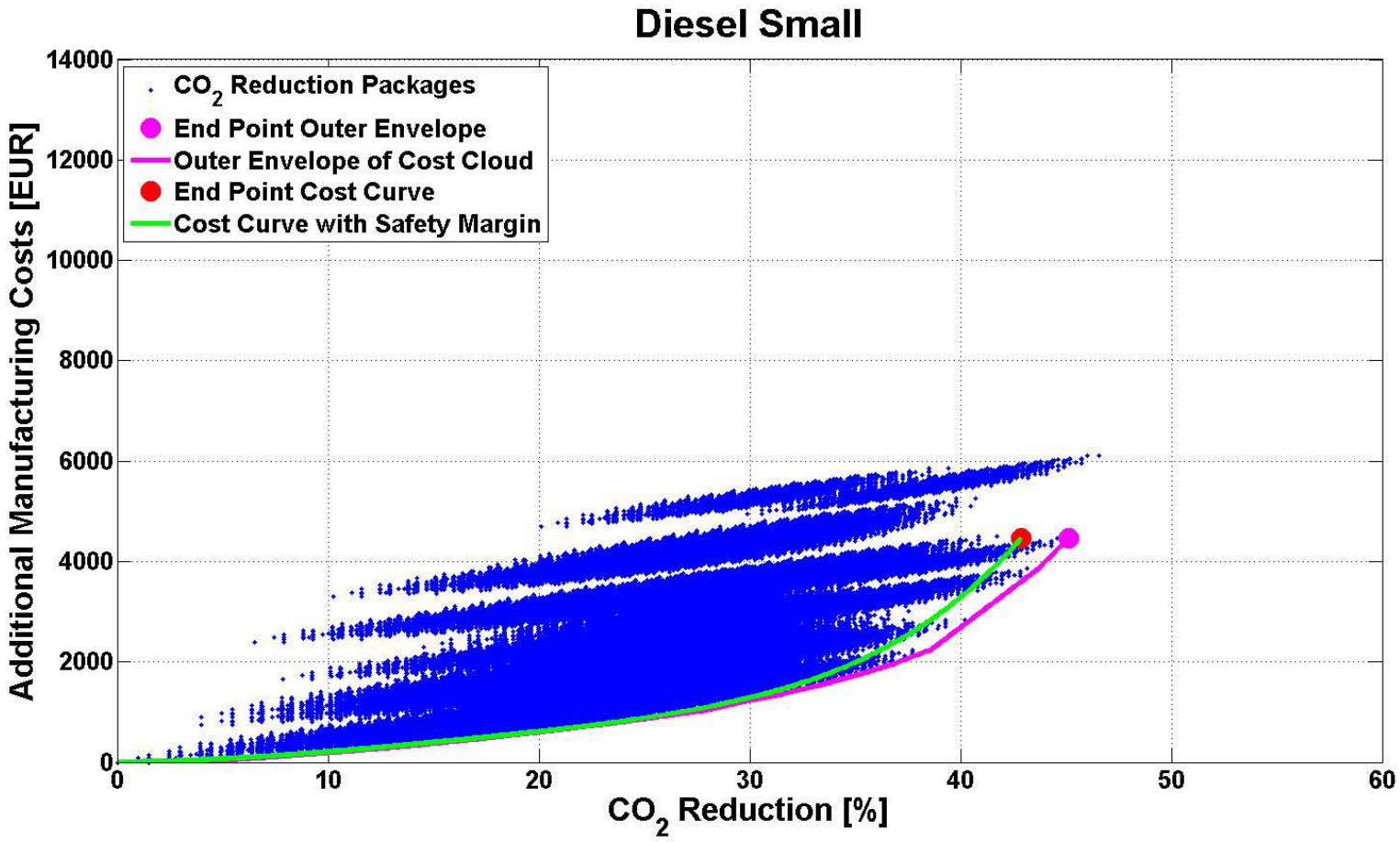
BACK-UP SLIDES

CO_2 reduction potential and additional manufacturer costs of technical options (diesel)

	Technology options for diesel LCVs	Small LCV		Medium LCV		Large LCV	
	Description	CO2 reduction potential [%]	Cost [EUR]	CO2 reduction potential [%]	Cost [EUR]	CO2 reduction potential [%]	Cost [EUR]
base engine	Combustion improvements	3,0	90	3,0	90	3,0	90
	Mild downsizing (15% cyinder content reduction)	4,0	50	4,0	50	3,0	50
	Medium downsizing (30% cylinder content reduction)	7,0	290	7,0	290	6,0	170
	Variable valve actuation	N/A	N/A	1,0	50	1,0	50
transmission	Optimising Gearbox ratios/downspeeding	1,0	0	1,0	0	1,0	0
	Improved M/T Transmission	0,5	0	0,5	0	0,5	0
	Downspeeding via slip controlled clutch and DMF deleted	3,0	120	3,0	120	3,0	120
	Automated manual transmission	6,0	300	6,0	300	6,0	500
	Dual (dry) clutch transmission	4,0	900	5,0	1100	N/A	N/A
Hybridisation/EV	Start stop	4,0	175	4,0	200	5,0	225
	Micro -hybrid (including regenerative braking)	6,0	350	7,0	375	8,0	400
	Mild hybrid (Torque boost for downsizing)	11,0	1400	11,0	1500	11,0	1600
	Full Hybrid (EV only mode)	25,0	2550	25,0	3050	25,0	4250
	Series Range extender with 40-50kW engine	45,0	10000	45,0	11000	45,0	11500
	Electric vehicle	100,0	30000	100,0	32000	100,0	33000
Driving resistance reduction	BIW lightweighting - mild (~10% reduction)	1,5	150	1,0	175	1,0	325
	BIW lightweighting - medium (~25% reduction)	4,0	750	2,5	875	2,5	1625
	BIW lightweighting - strong (~40% reduction)	6,5	2400	4,0	2800	4,0	5200
	Lightweight components other than BIW	1,5	150	1,0	175	1,0	325
	Aerodynamics improvement - minor	1,5	50	2,0	100	1,5	100
	Aerodynamics improvement - major	3,0	150	3,0	200	3,0	250
	Low rolling resistance tyres	4,0	150	5,0	200	5,0	300
	Reduced driveline friction (mild reduction)	1,0	80	1,0	80	1,0	90
	Reduced driveline friction (high reduction)	3,0	210	3,0	220	3,0	250
Other	Thermo-electric generation	N/A	N/A	2,5	300	4,0	400
	Secondary heat recovery cycle	N/A	N/A	4,0	400	5,0	600
	Auxilliary (thermal) systems improvement	2,5	70	2,8	80	3,2	80
	Auxilliary systems improvement (lubrication, vacuum, FIE)	2,8	85	3,5	100	3,7	115
	Other Thermal management	1,5	80	2,2	120	2,5	170
	Electrical assisted steering (EPS, EPHS)	N/A	N/A	N/A	N/A	3,0	150



Cost curve example for Class I diesel



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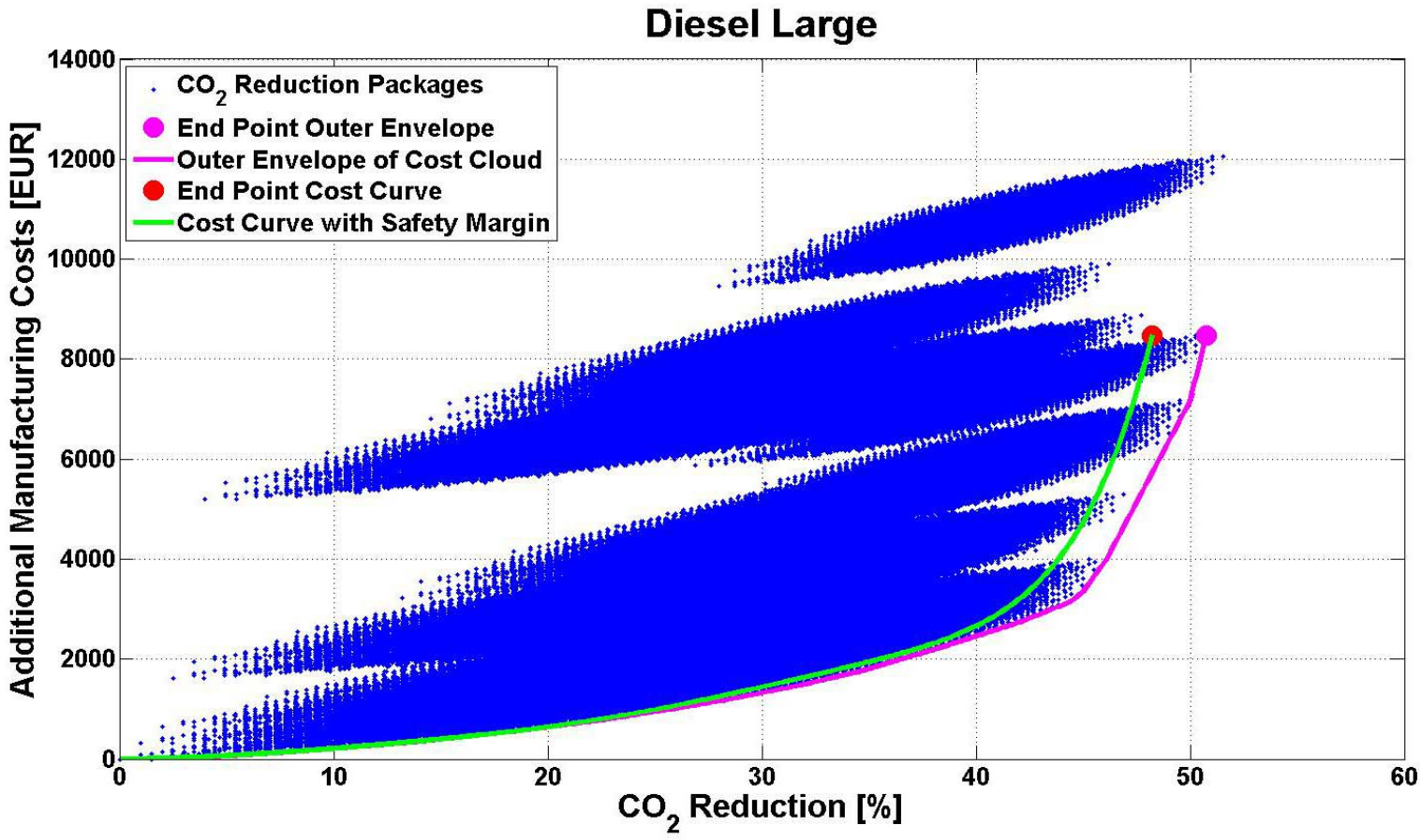
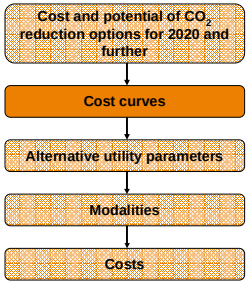
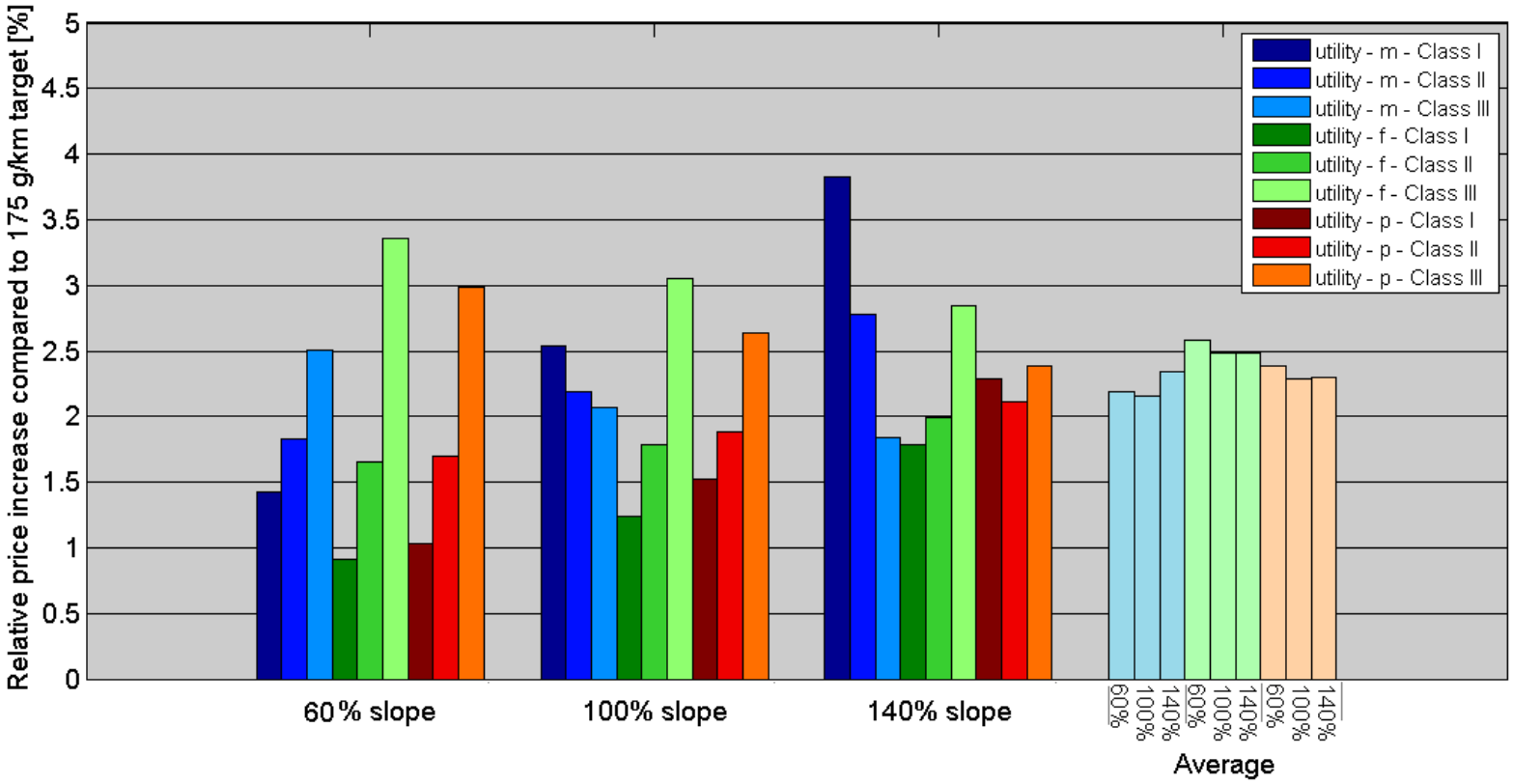
Cost curve example for Class III diesel





Relative price increase relative to 175 gCO_2/km



- Even distribution of burden only achieved for high slope values for Footprint and Payload (at 140% slope). Such steep slopes offer room for gaming.
- **Conclusion**: Footprint and Payload are not preferable utility parameters

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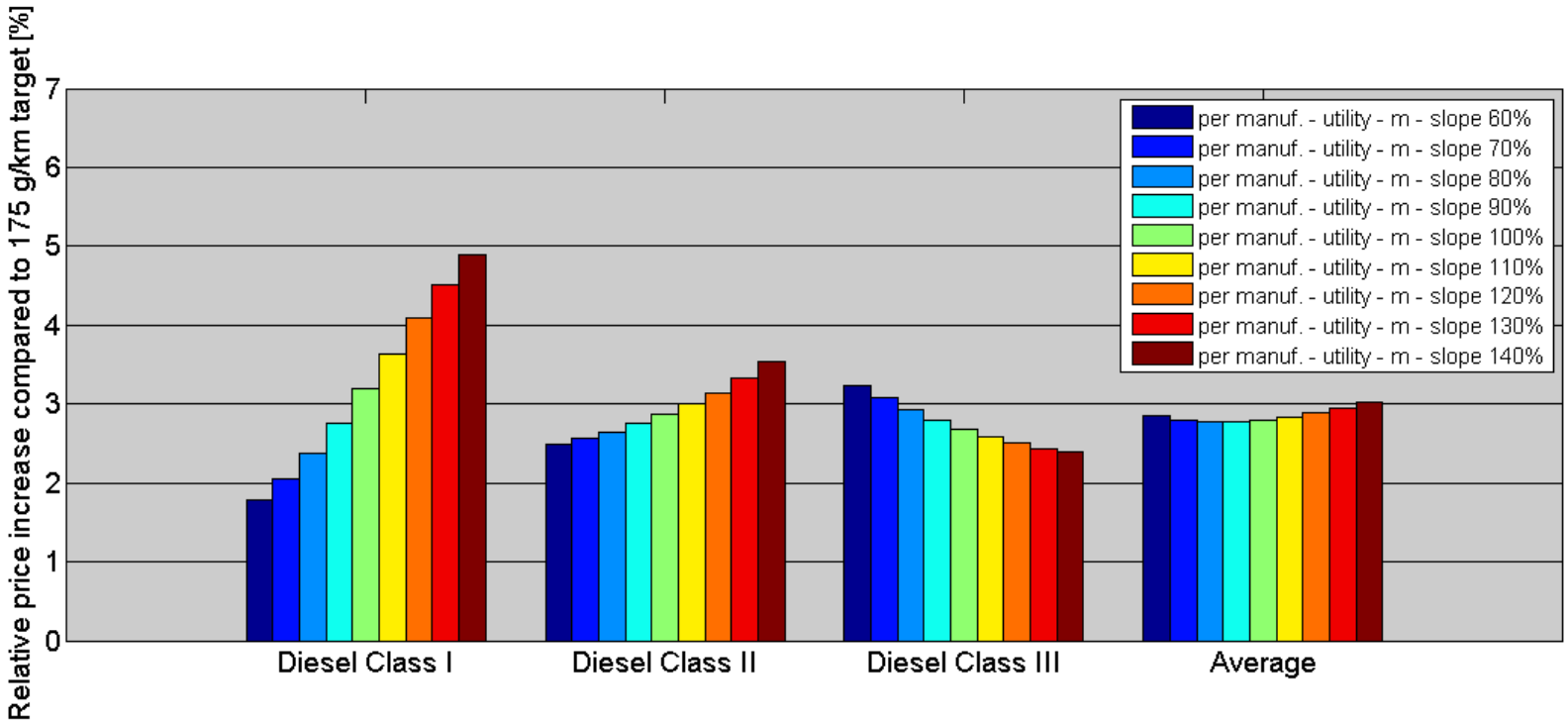
Relative price increase is most evenly distributed close to 100% slope



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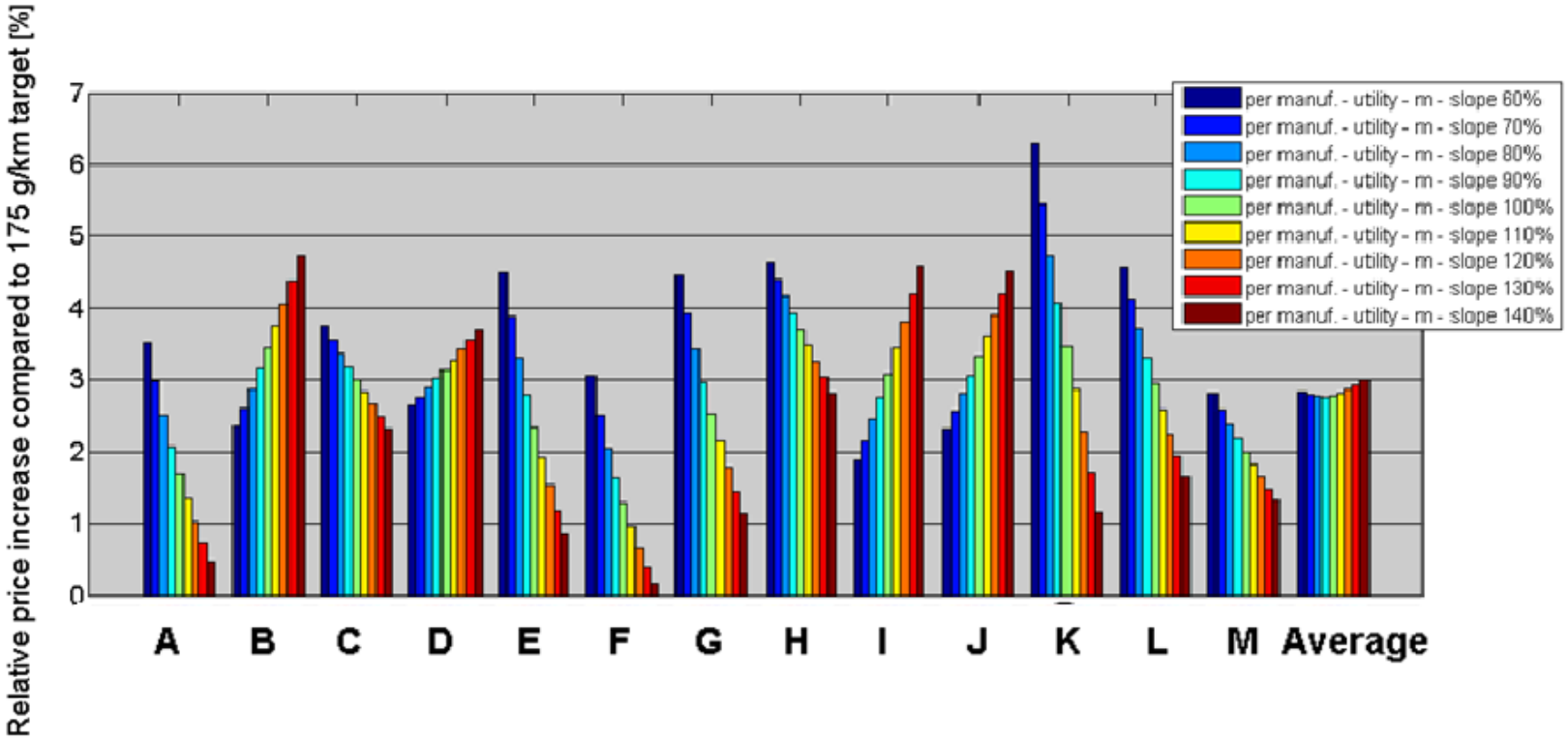
Relative price increase is most evenly distributed over manufacturers close to 100% slope



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