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Improving the understanding of the potential for weight reduction in cars and vans

Passenger car and van CO_2 regulations – stakeholder meeting

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Background to the study

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- Still significant debate on the optimal utility parameter
- Previous work has shown that mass and footprint are the most credible options
- However, critics argue that mass disincentivises vehicle weight reduction
- Hence, manufacturers might not adopt the most cost effective strategies for reducing vehicle CO_2 emissions
- OEMs indicate that weight reduction is an important strategy, but average new vehicle mass continues to increase
- For post-2020/21 time period, it is important to understand the relative attractiveness of weight reduction
- Will help inform discussions on the stringency of future CO_2 targets and choice of utility parameter

Study aims and objectives

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- Analysis of recent EU trends in the mass of cars and vans
- Impacts of weight reduction on manufacturer targets under the current Regulations
- Potential for applying weight reduction measures to light duty vehicles
- Review of key US studies on vehicle weight reduction
- Stakeholder consultation
- Exploring the impact of footprint versus mass-based utility parameters
- Alternative options for ensuring weight reduction is as attractive as other options for reducing CO_2 emissions

Recent trends in vehicle mass – passenger cars

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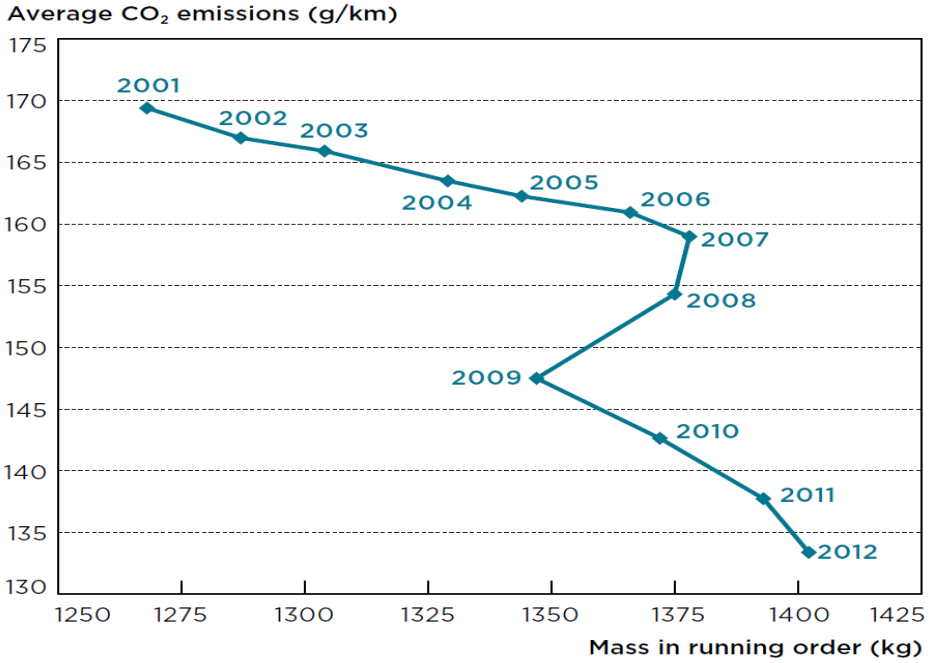
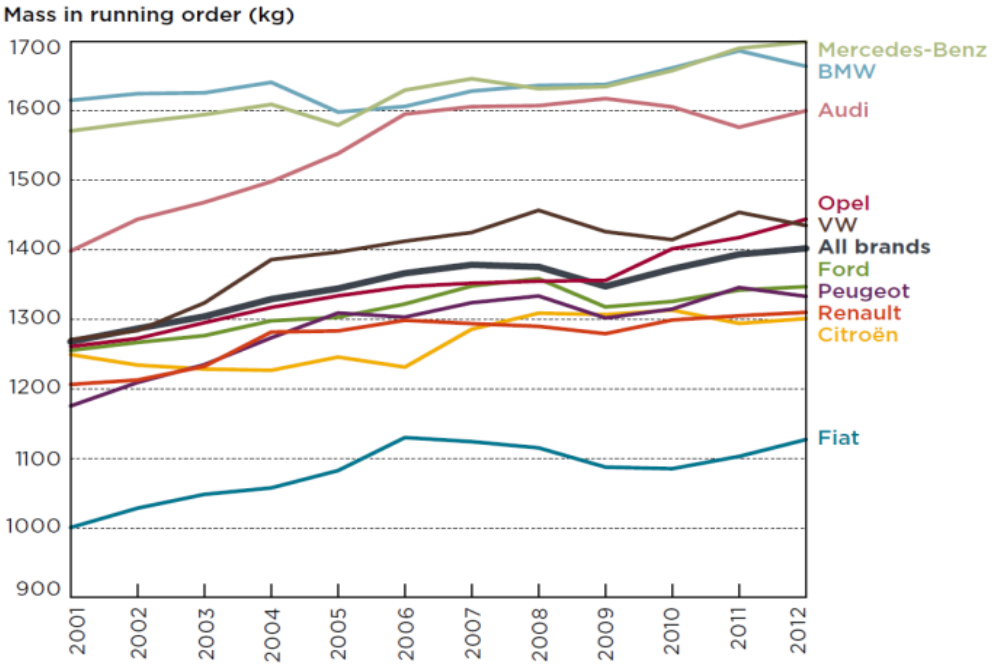
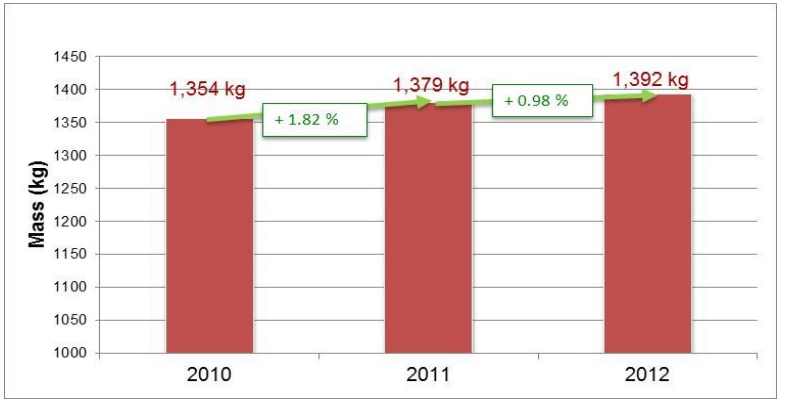
Long term upward trend – across all brands



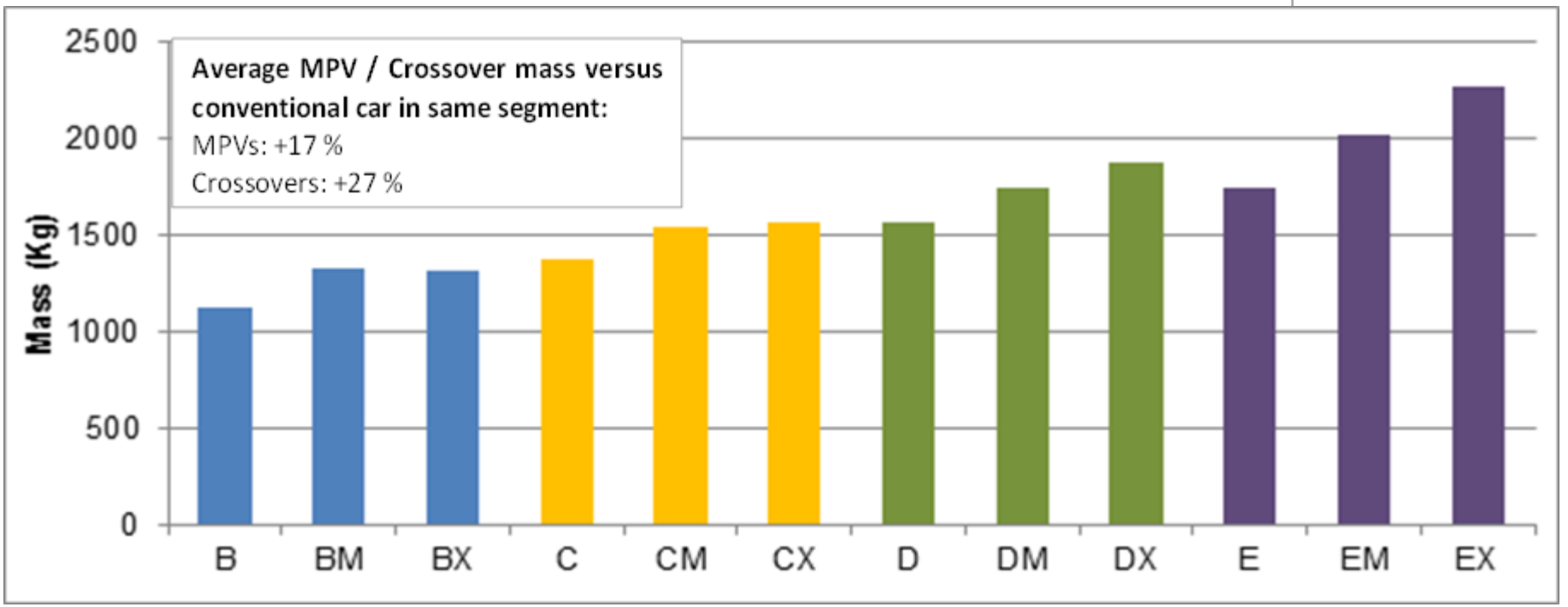


- Average sales weighted mass has seen long term upward trend
- Trend is observed across all brands, all segments and for individual models

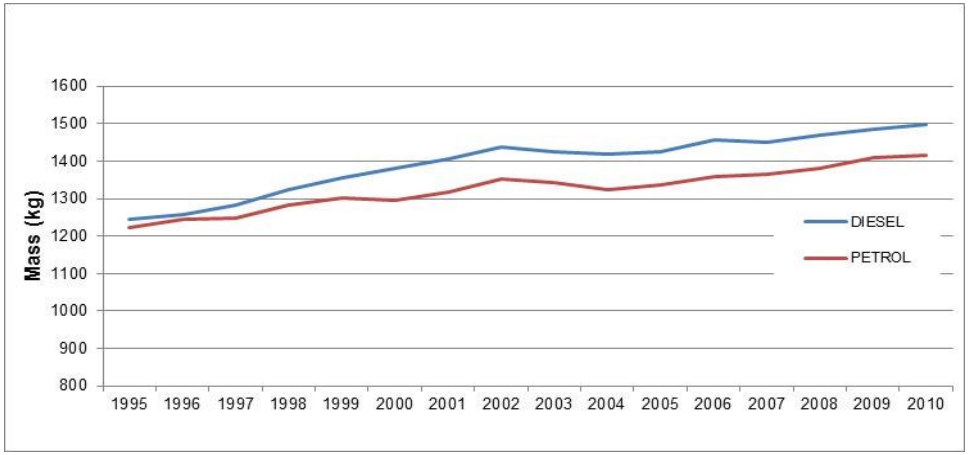


(source of upper plots: ICCT)

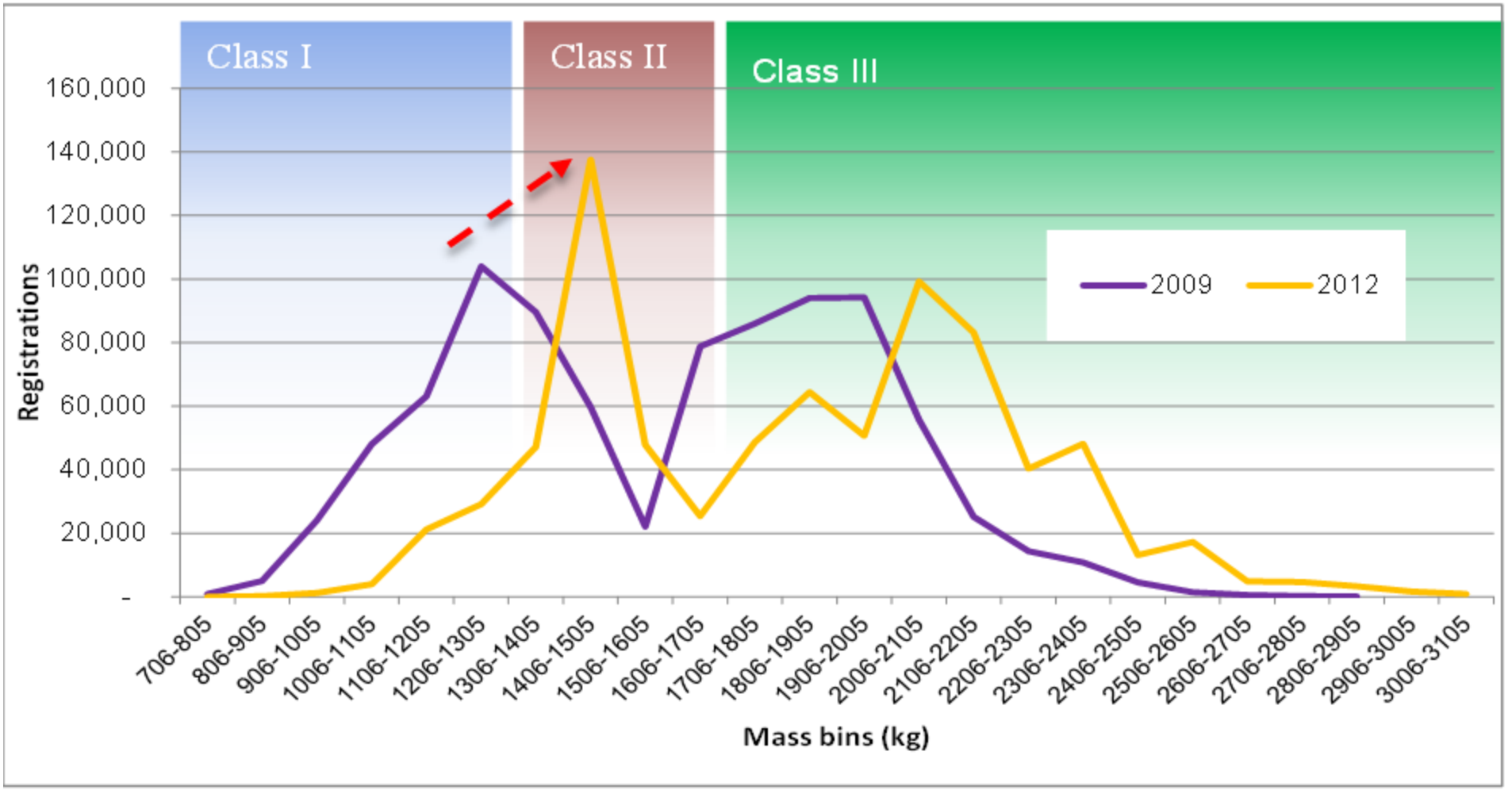
Recent trends in vehicle mass – passenger cars



- MPVs and particularly crossovers significantly heavier than conventional cars – typically about the same as conventional car in next larger segment
- A further driver for passenger car weight increase is the continuing trend of increasing diesel market share



Recent trends in vehicle mass – vans



- Shift is due to latest versions of popular models shifting up a class

Scenario analysis: impacts of weight reduction on manufacturer targets under the current Regulations

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Scenario	Utility parameter	Weight reduction of "Manufacturer A"	Average weight change of other manufacturers	Subsequent change in average weight of market
BAU	Mass	0%	None	0%
1	Mass	10%	None	Down by 1%
2	Mass	10%	Up by 10%	Up by 8%
3	Mass	10%	Down by 10%	Down by 10%
4	Mass	0%	Down by 10%	Down by 9%
5	Footprint	10%	Not relevant for target of Manufacturer A	Not relevant for target of Manufacturer A

- For all scenarios, three versions were explored, where "Manufacturer A" (i.e. the one taking the action to reduce the weight of its cars in most scenarios) was:
  - an 'average' manufacturer
  - a 'heavier' manufacturer; and
  - a 'lighter' manufacturer.

Impacts of weight reduction on manufacturer targets under the current Regulations

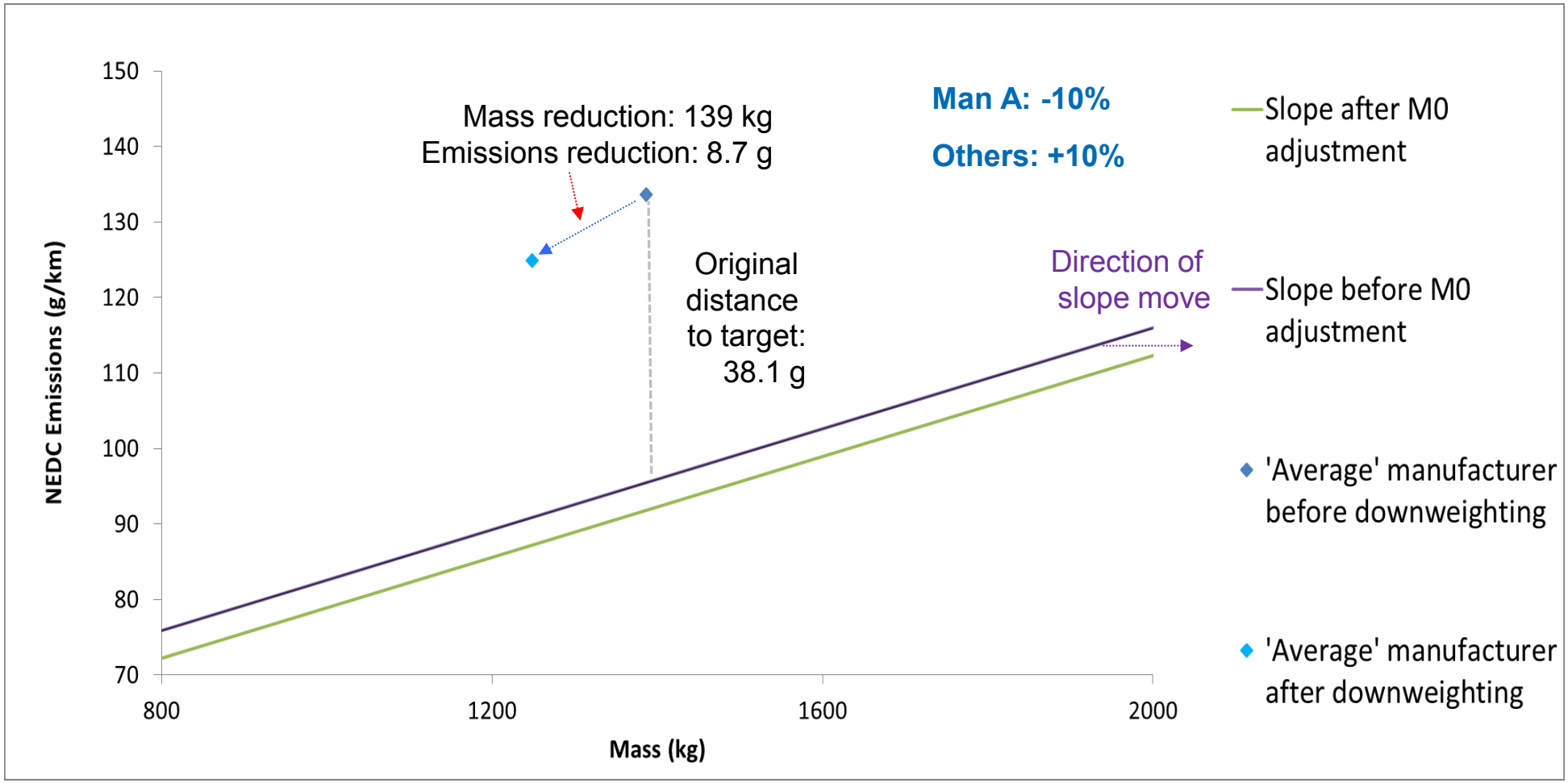
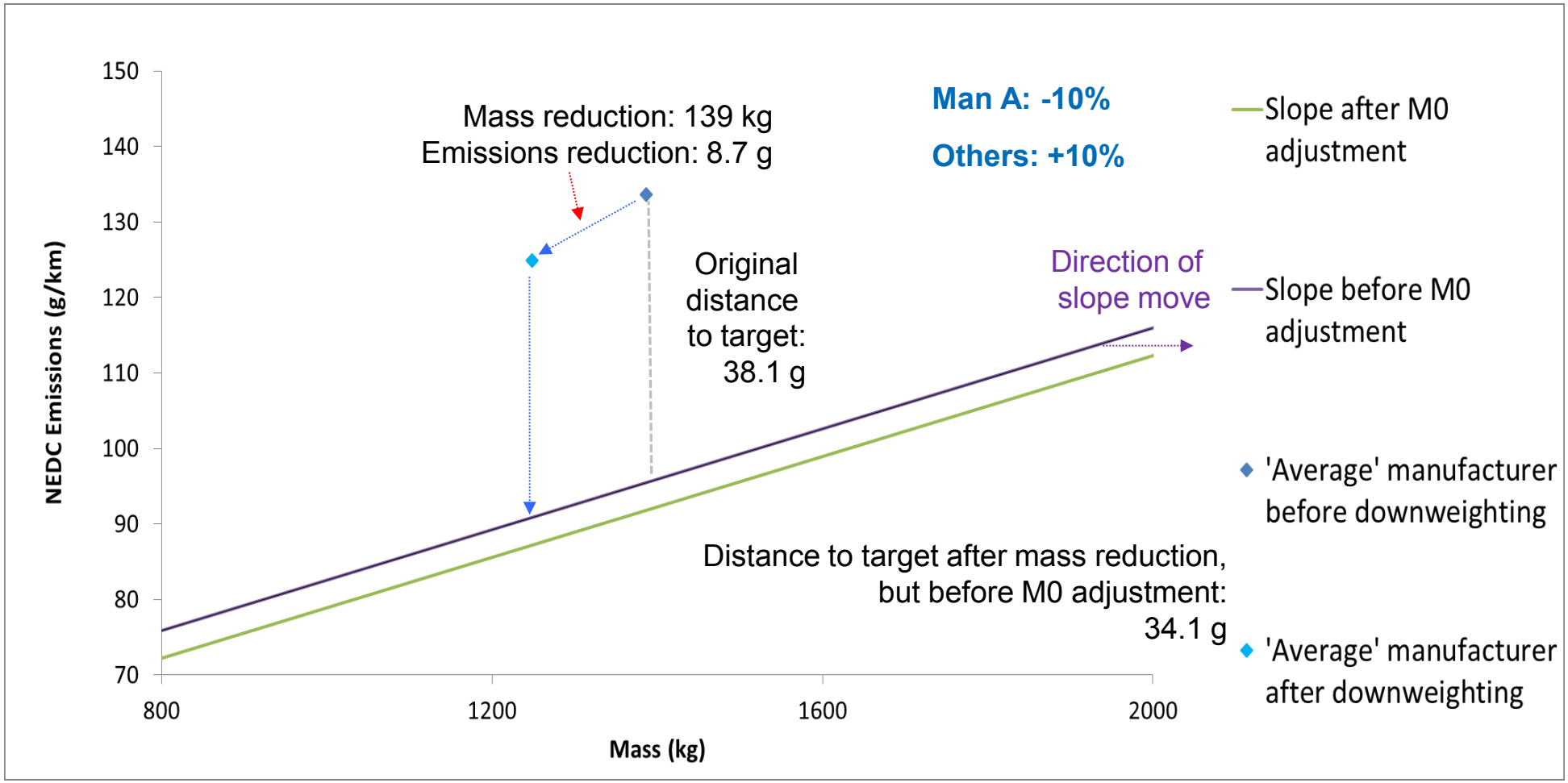


Figure: Representation of results for an 'average' manufacturer in Scenario 2

Impacts of weight reduction on manufacturer targets under the current Regulations



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Impacts of weight reduction on manufacturer targets under the current Regulations

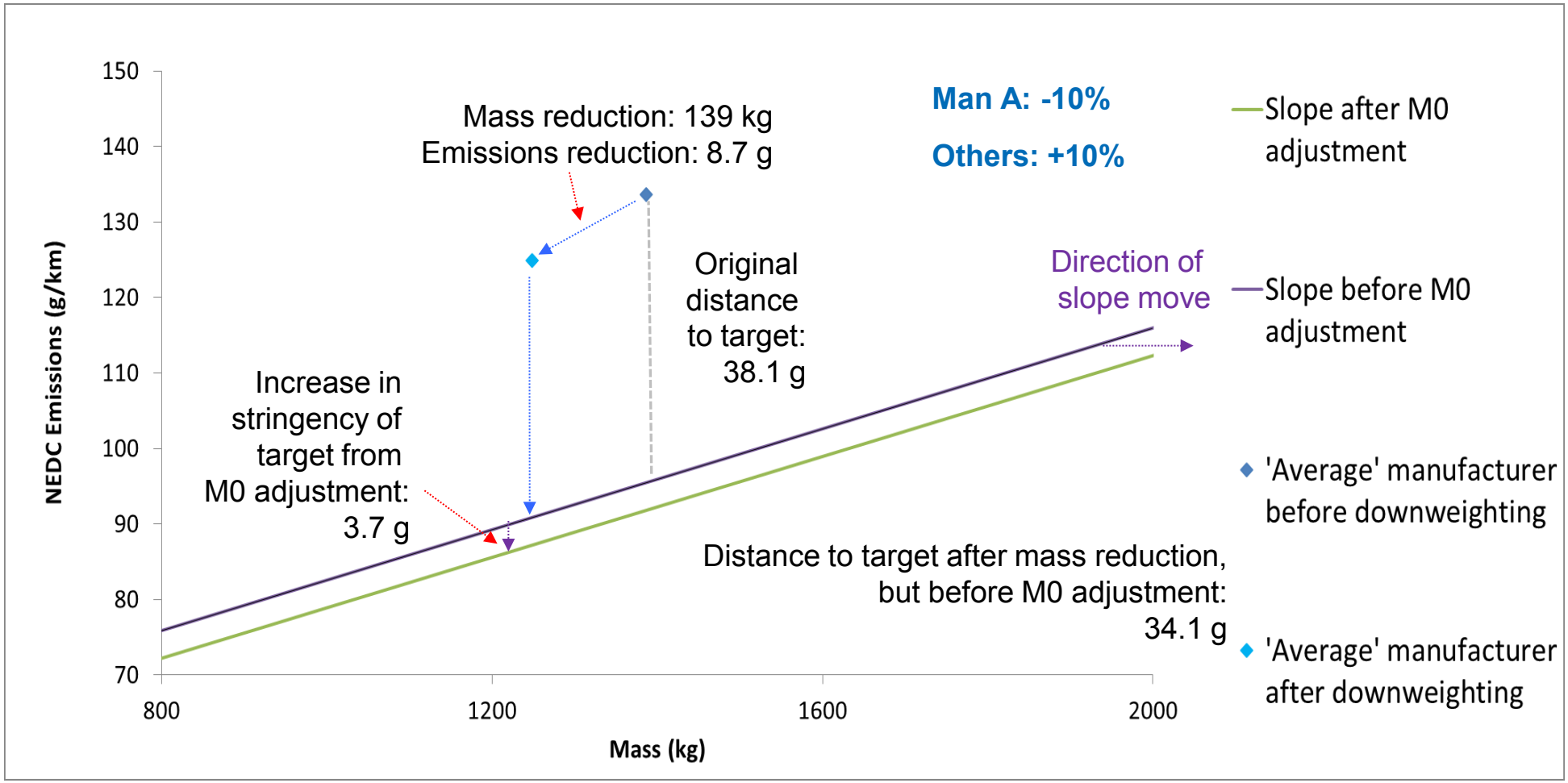

Figure: Representation of results for an 'average' manufacturer in Scenario 2

Impacts of weight reduction on manufacturer targets under the current Regulations

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- Where 'mass' is the utility parameter, distance to target for any manufacturer will depend to some extent on the action of its competitors, as a result of potential M_0 adjustment

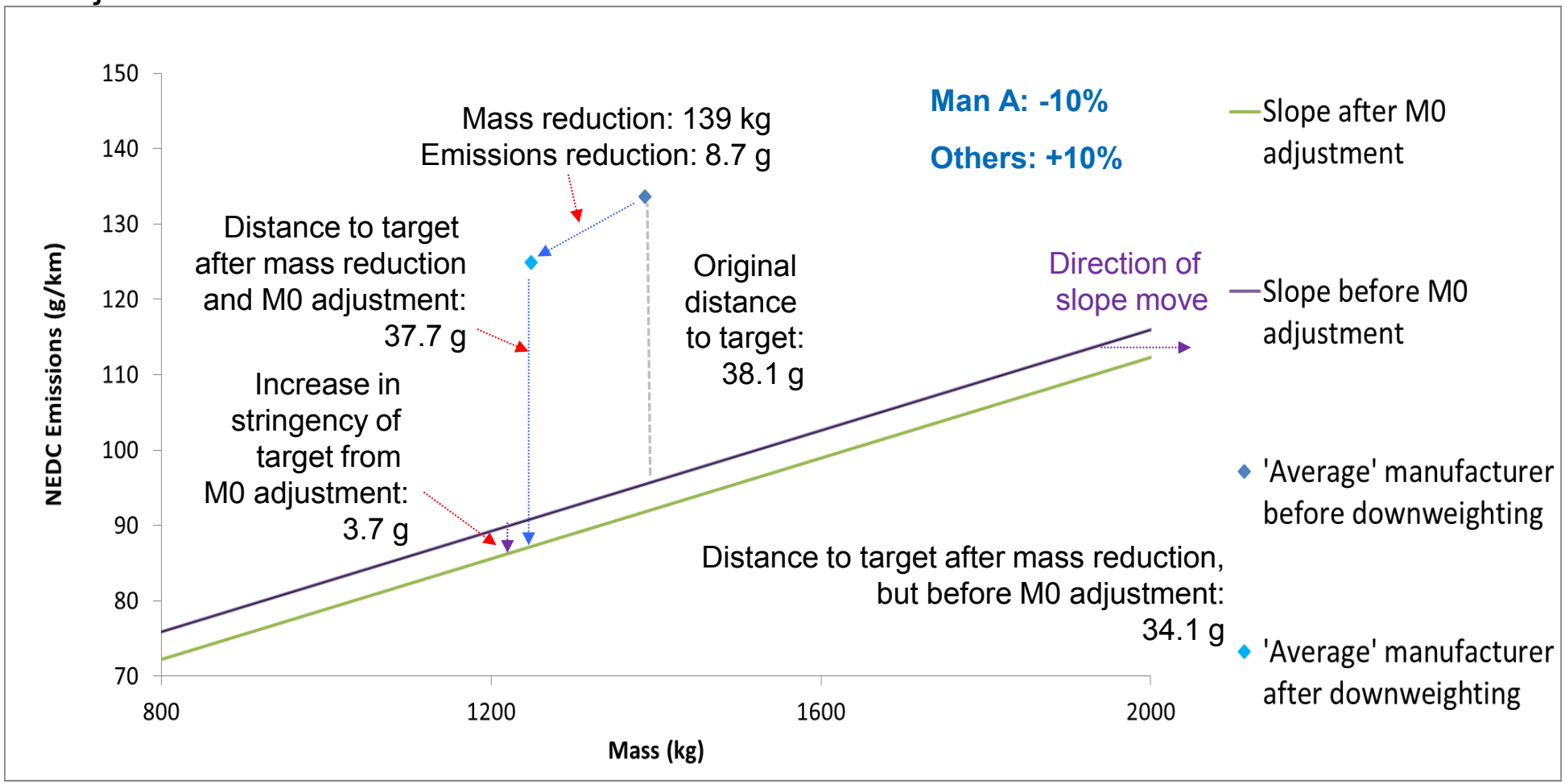

Figure: Representation of results for an 'average' manufacturer in Scenario 2

Comparing the graphs….

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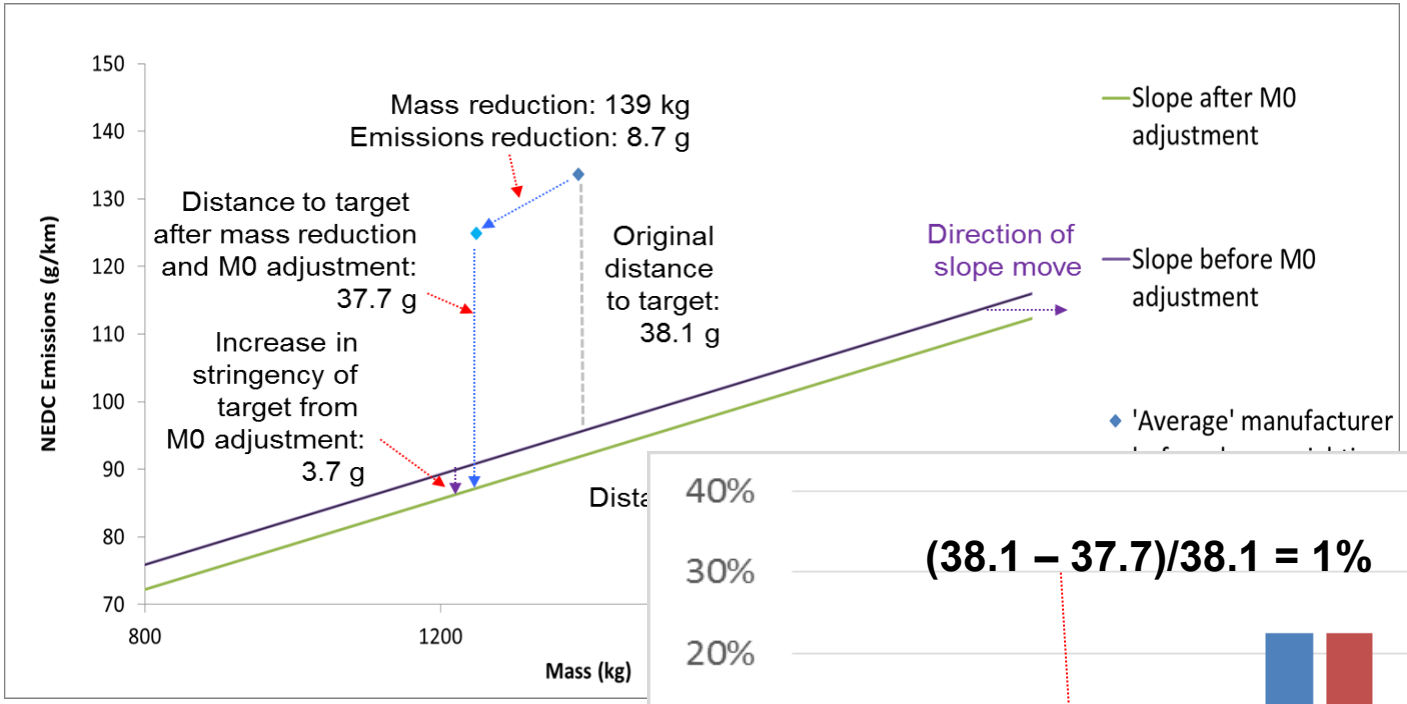

Figure 1: Representation of results for an 'average' manufacturer in Scenario 2

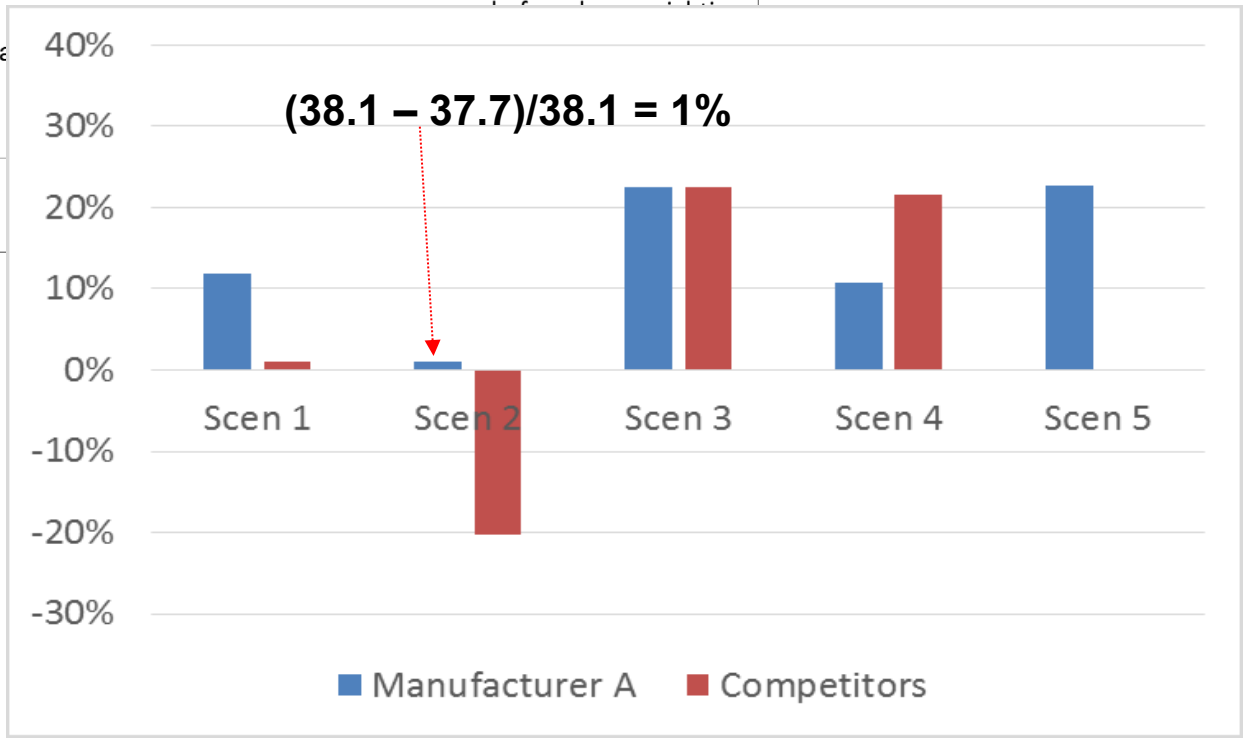

Figure 2: Distance closer to target as a proportion of original distance to target for an 'average' manufacturer and its competitors after mass reduction and M0 adjustment

Impacts of weight reduction on manufacturer targets under the current Regulations

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- A manufacturer that takes action to reduce the weight of its cars will always be closer to its target, whether the utility parameter is 'mass' or 'footprint'

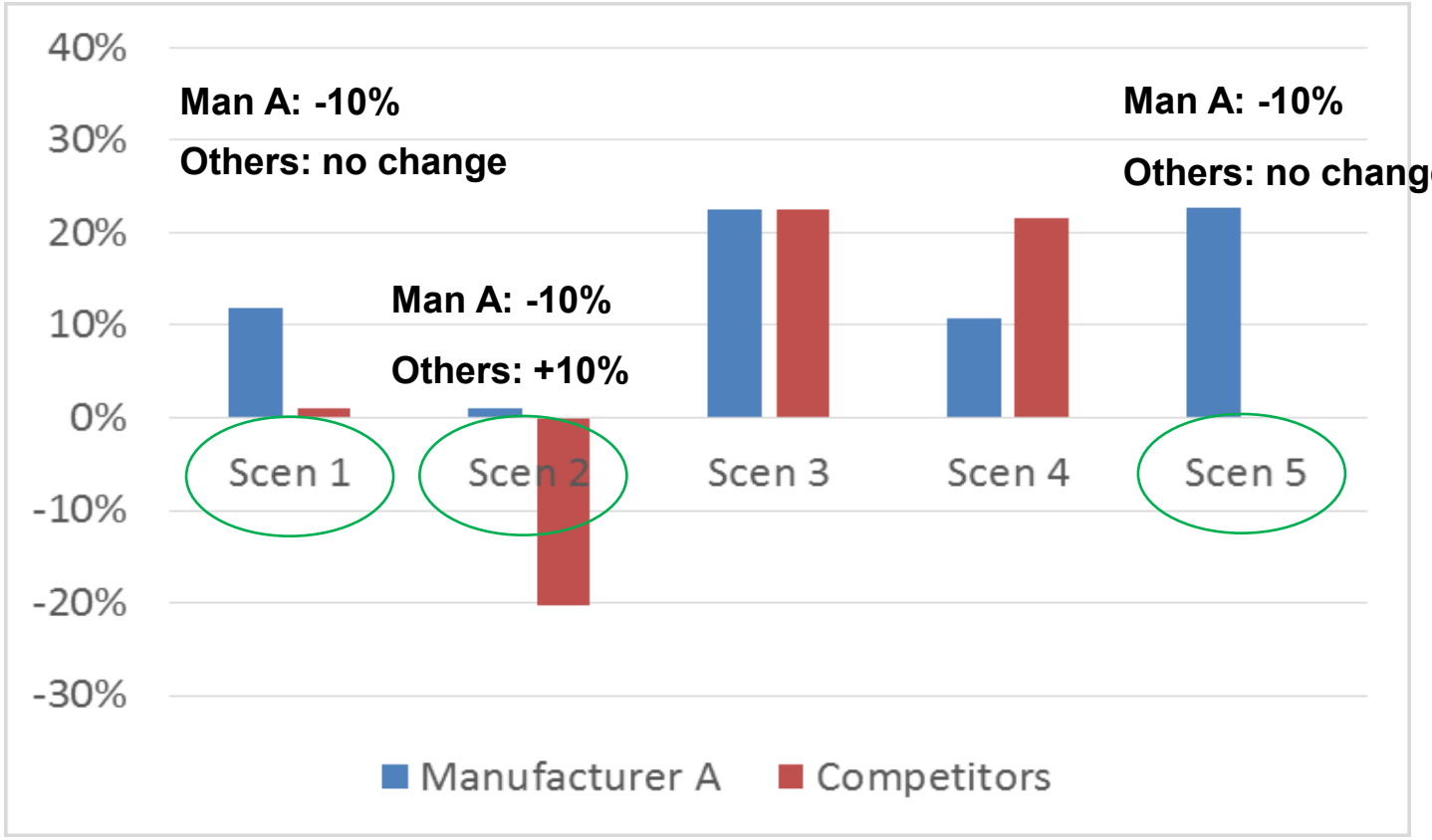

Figure: Distance closer to target as a proportion of original distance to target for an 'average' manufacturer and its competitors after mass reduction and M0 adjustment

Impacts of weight reduction on manufacturer targets under the current Regulations

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- If a manufacturer does not take action to reduce the mass of its new cars, but its competitors do, it would benefit (in terms of a less stringent target) from the actions of others, although its competitors would be proportionately closer to their targets

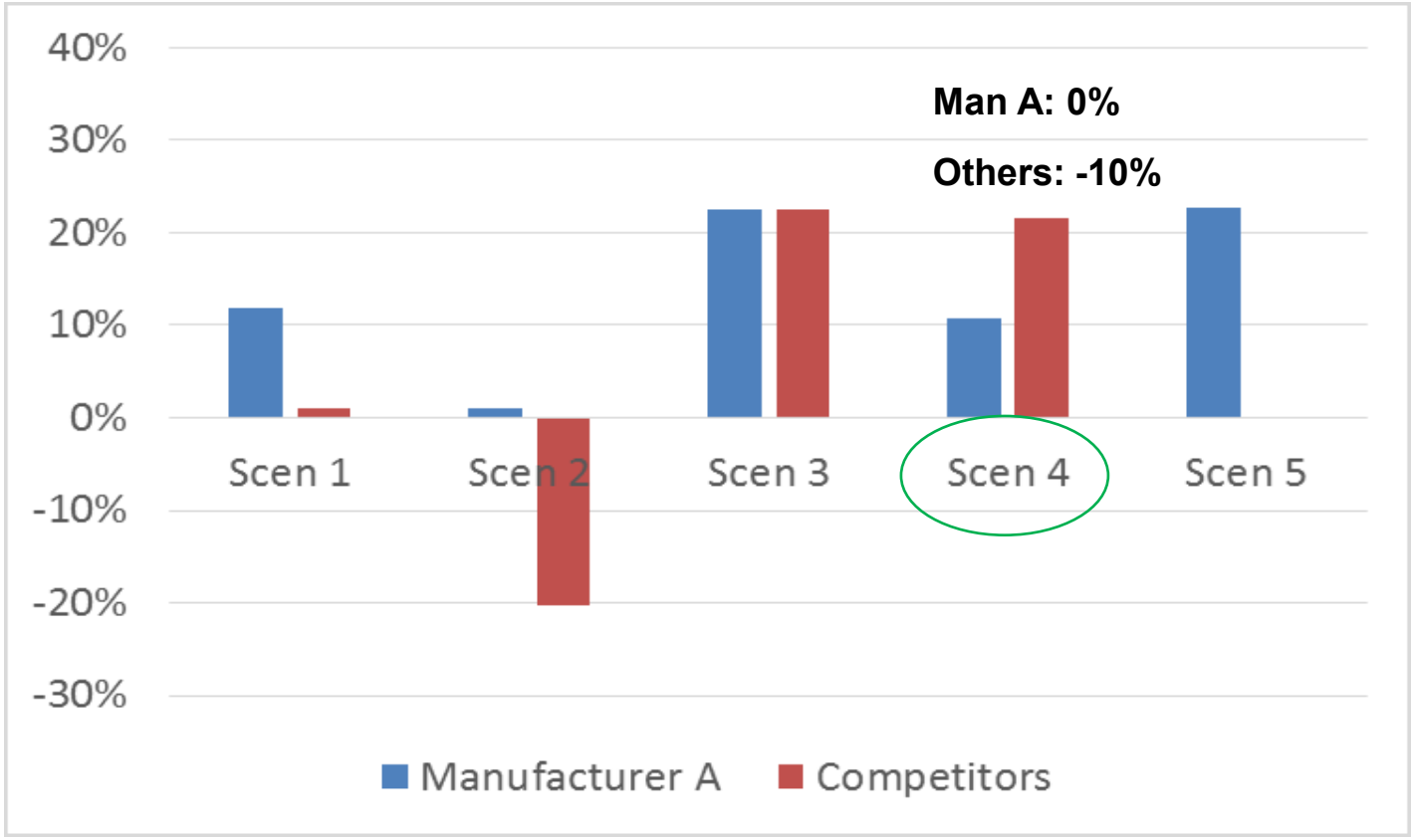

Figure: Distance closer to target as a proportion of original distance to target for an 'average' manufacturer and its competitors after mass reduction and M0 adjustment

Impacts of weight reduction on manufacturer targets under the current Regulations

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- If the average mass of the market was increasing, the potential benefit to a manufacturer of taking action to reduce the mass of its cars would be negated by the impact of the M_0 adjustment, although it would be in a better position compared to its competitors (%s compared to BAU)

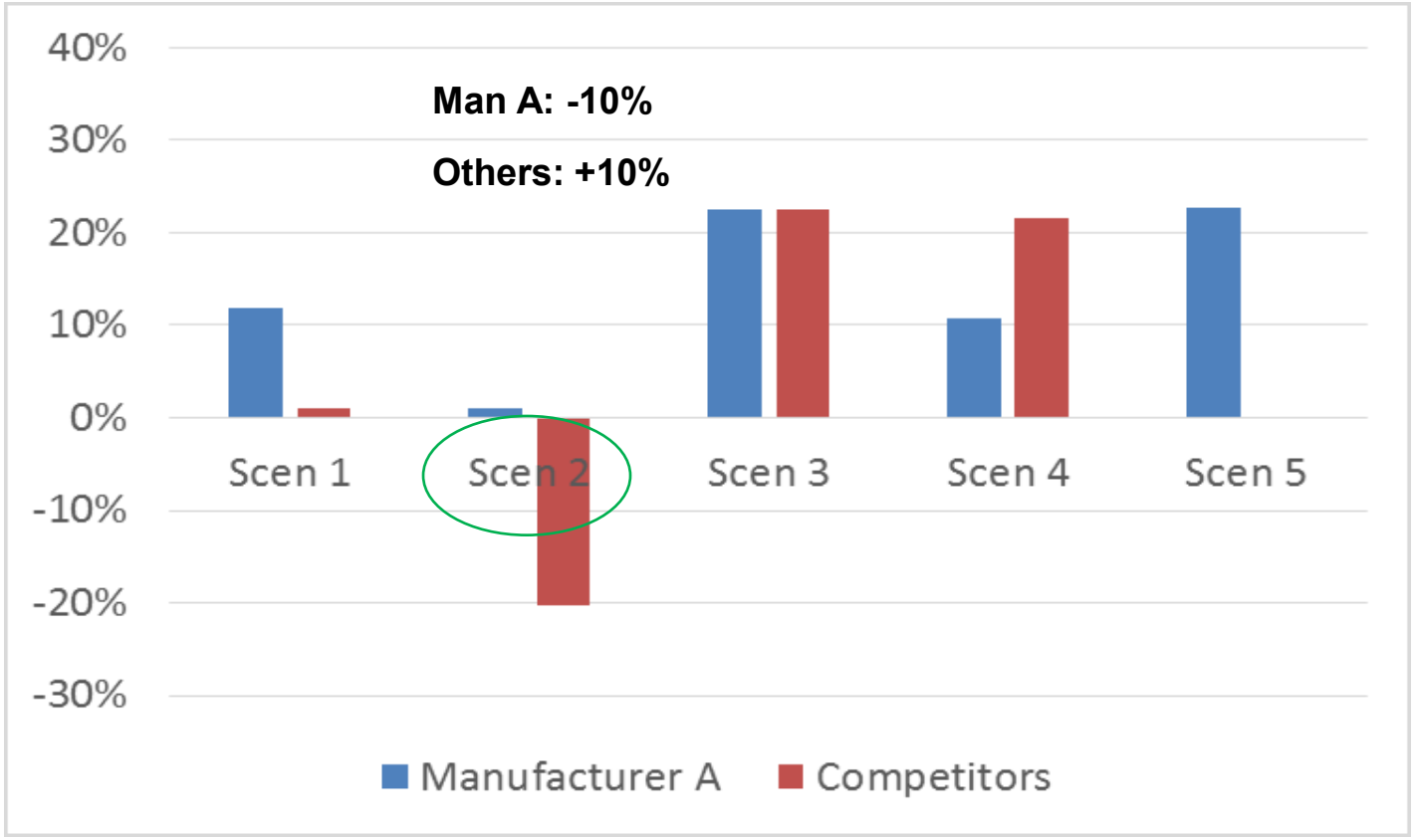

Figure: Distance closer to target as a proportion of original distance to target for an 'average' manufacturer and its competitors after mass reduction and M0 adjustment

Impacts on “lighter” vs “heavier” manufacturer fleets

- A lighter manufacturer will generally benefit more proportionately (in terms of distance to its target) from the same proportion of weight reduction than a heavier manufacturer, and this is independent of the utility parameter used…

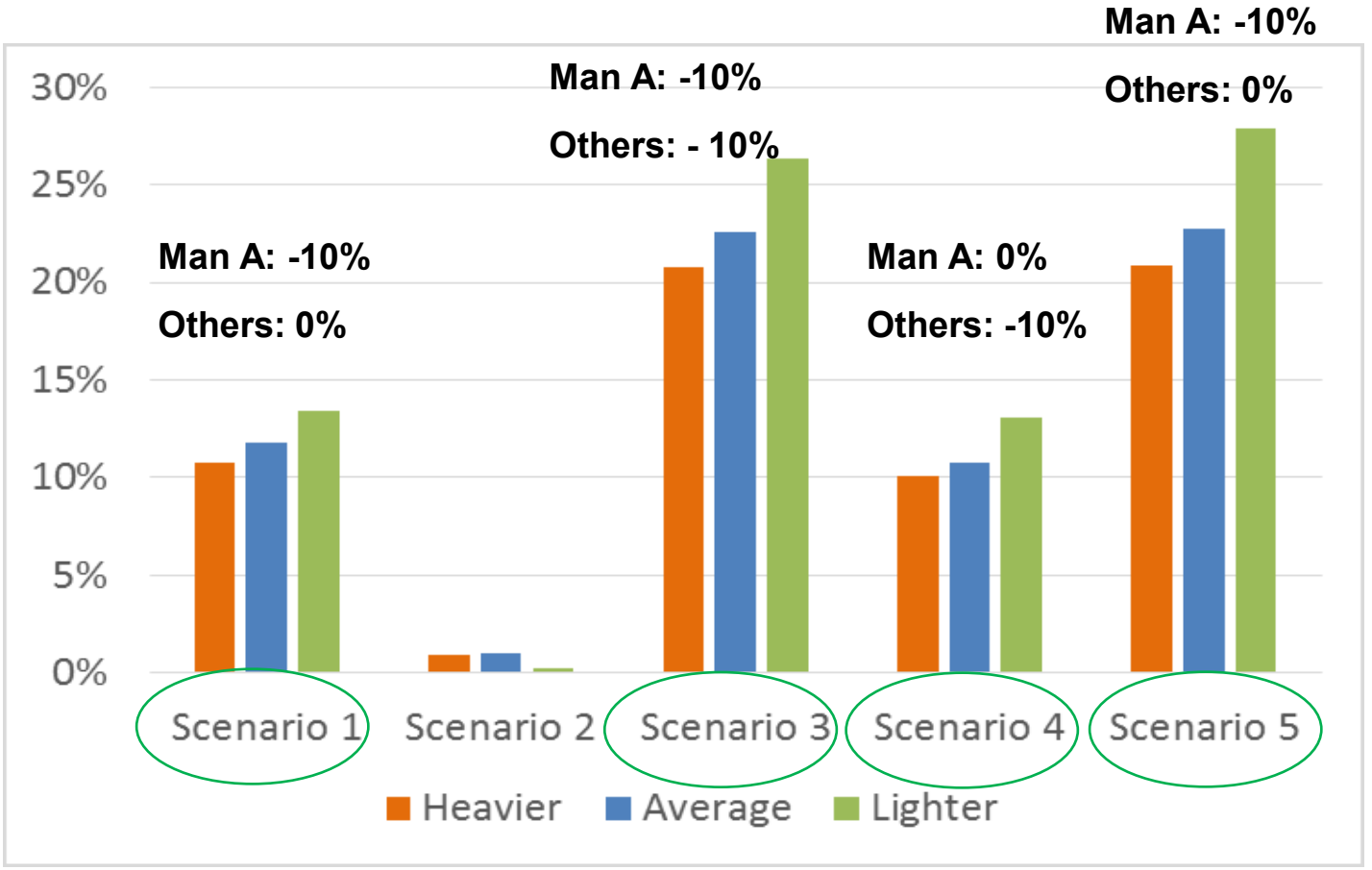

Figure: Distance closer to target as a result of mass reduction (and M_0 adjustment, where relevant) as a proportion of the original distance to its target, by type of manufacturer

Impacts on “lighter” vs “heavier” manufacturer fleets

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- … except for when the average mass of the market was increasing, as lighter manufacturers suffer more from the effect of the Mo adjustment

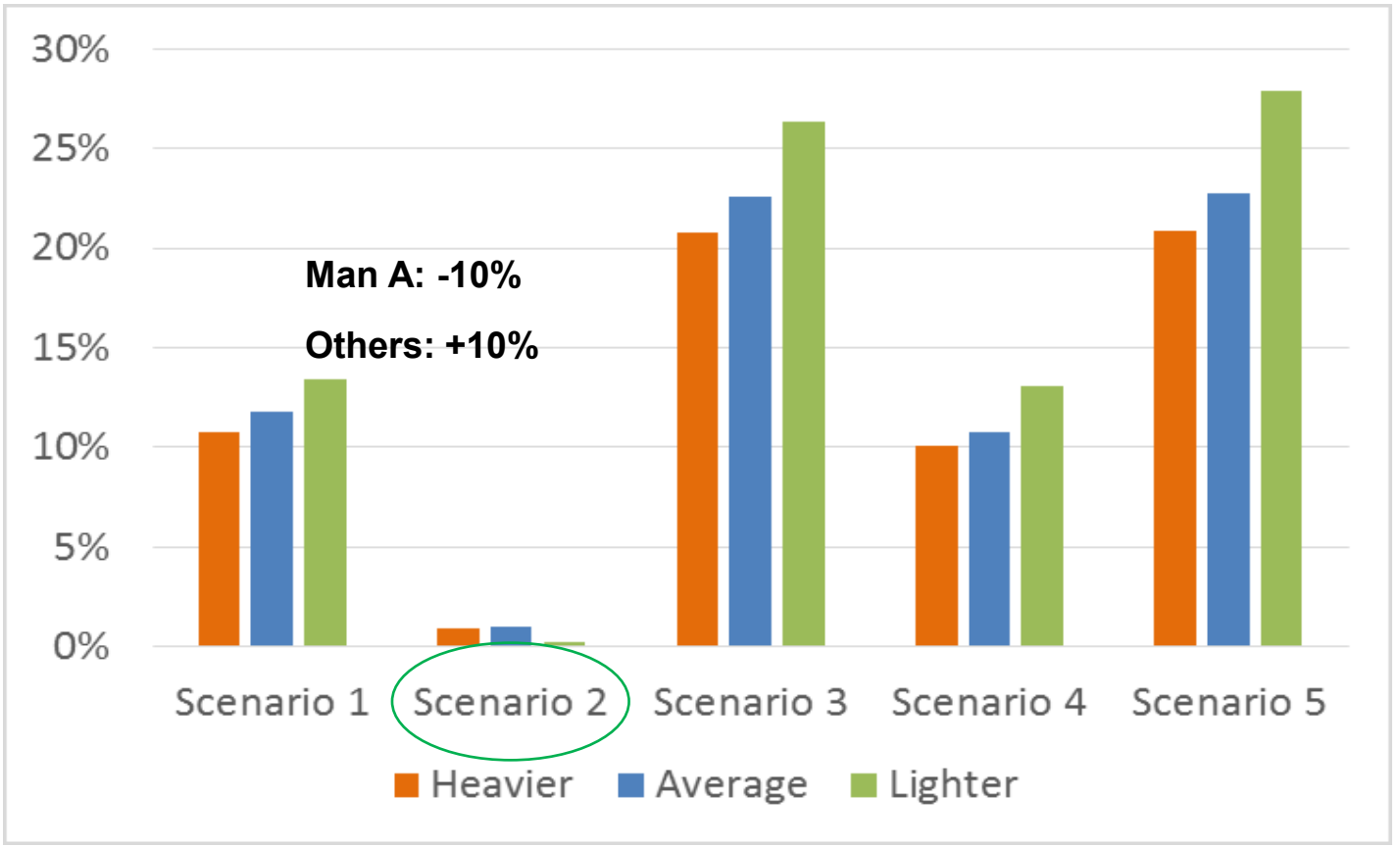

Figure: Distance closer to target as a result of mass reduction (and M_0 adjustment, where relevant) as a proportion of the original distance to its target, by type of manufacturer

Impacts of weight reduction on manufacturer targets under the current Regulations

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- **Scenarios illustrate that:**
  - Weight reduction always brings a manufacturer closer to its target
  - However mass as utility parameter increases the cost and risk for first movers
  - Mass as utility parameter increases the likelihood that a manufacturer benefits from reductions in weight made by rival manufacturers
  - Weight reduction is more attractive for OEMs that sell heavier vehicles when the average mass of the market is increasing

Potential for applying weight reduction measures to light duty vehicles

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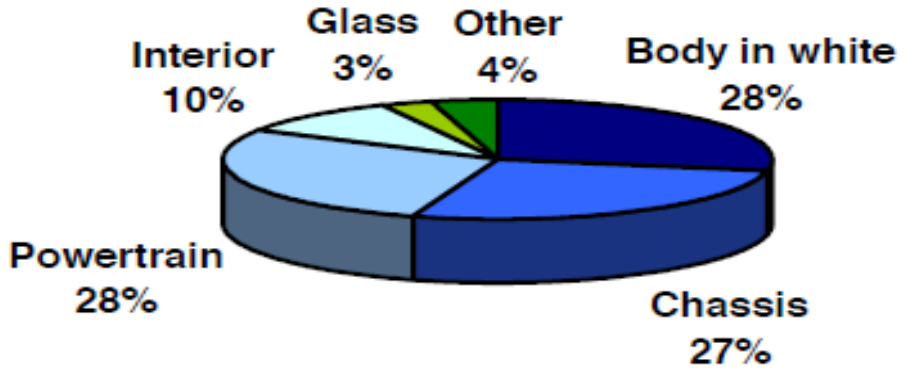
- Typically, three vehicle systems account for more than 80% of the weight of a vehicle:
  - Body-in-white
  - Chassis
  - Powertrain



- Study focused on examining weight reduction options for these three systems
- Weight reduction strategies include:
  - Use of lightweight materials
  - Optimising or improving existing designs
  - Re-sizing parts and systems
  - Removing content or features
  - Revising manufacturing or assembly operations

Weight reduction options: Body-in-white and closures

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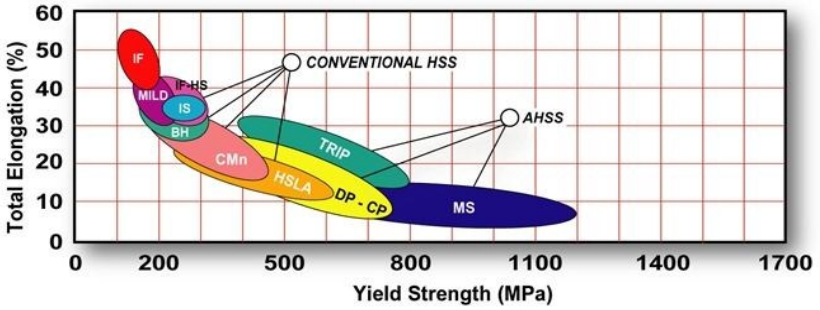
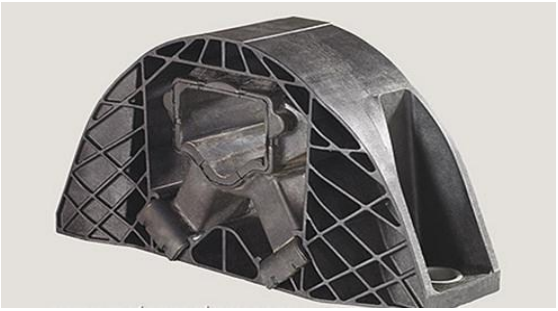
- **Materials options include:**
  - Increased use of Advanced High Strength Steels
  - Increased use of Aluminium (both in terms of fully-aluminium bodyshells and hybrid aluminium/steel approaches
  - Selective use of magnesium for body panels (e.g. tailgate inner panels and inner door panels)
  - Plastics and composite materials
- **Barriers to take-up include:**
  - Prices of materials
  - Changes in manufacturing processes
  - Production cycle times (e.g. moulding of composite panels)
- **No single "best-fit" option**
  - Future solutions are likely to be based around multi-material strategies



Weight reduction options: Powertrain

- **Options include**
  - Alternative materials
    - Use of magnesium for engine blocks
    - Composites and other plastics for various engine components, including oil sumps, manifolds, engine mounts, and even engine blocks
    - Engine downsizing
- **Additional benefits:**
  - Plastics are already used for some engine components with the main aim of cutting parts count to save cost
  - Weight reduction is a side benefit
- **Potential barriers**
  - Ensuring that alternative materials meet durability requirements

Magnesium engine block



Plastic engine mount

Downsized engines

Weight reduction options: Chassis systems

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- **Chassis systems comprise**
  - Suspension components
  - Braking system
  - Steering system
  - Wheels/tyres
- **Suspension components**
  - Aluminium (e.g. knuckles and control arms)
  - Composite leaf springs
- **Braking systems**
  - Design optimisation (e.g. of rotors)
  - Electronic parking brakes
- **Steering systems**
  - Electric power assisted steering (EPAS)
- **Wheels/tyres**
  - Forged aluminium wheels (as opposed to casting)
  - High strength steel wheels
  - Hybrid aluminium/composite wheels

Composite leaf springs

Electronic parking brake

Prototype CFRP wheel

Other weight reduction options

- **Applying weight reduction technologies to other areas of the vehicle**
  - Light-weight interior trim materials and fascia components
  - Polycarbonate glazing
  - Downsized / design-optimised auxiliary equipment (e.g. HVAC systems)
  - Lightweight insulation materials and structural foams
- **Removing content or features from the vehicle**
  - New Citroen C4 Cactus provide a good example of techniques that can help to reduce weight whilst saving cost
    - One-piece rear seat (no split/fold facility)
    - Rear windows do not wind down (hinged instead)
    - Platform engineered for max speed of 190 km/h
      - Allows for downsized braking, suspension and cooling systems

Polycarbonate glazing – Volkswagen XL1

Citroen C4 Cactus

Detailed review of key US studies on vehicle weight reduction

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Four key US studies reviewed

- Lotus (2010) – Toyota Venza 2009 - whole vehicle
- Lotus (2012) – Toyota Venza 2009 – body structure
- NHTSA (2012) – Honda Accord 2011 – whole vehicle
- US EPA (2012) - Toyota Venza 2009 – whole vehicle

Findings suggest weight reduction can be achieved for significantly *lower* costs than previously thought:

– The US EPA Toyota Venza study indicates an **18.3% weight reduction** could be achieved with a ***reduction*** **in direct costs of 0.9% (about €100 saving)**

– The NHTSA Honda Accord study suggests a **22.4% weight reduction** could be achieved with an **increase in direct costs of 1.5% (about €240 increase)**

Relevance of US studies in the European context

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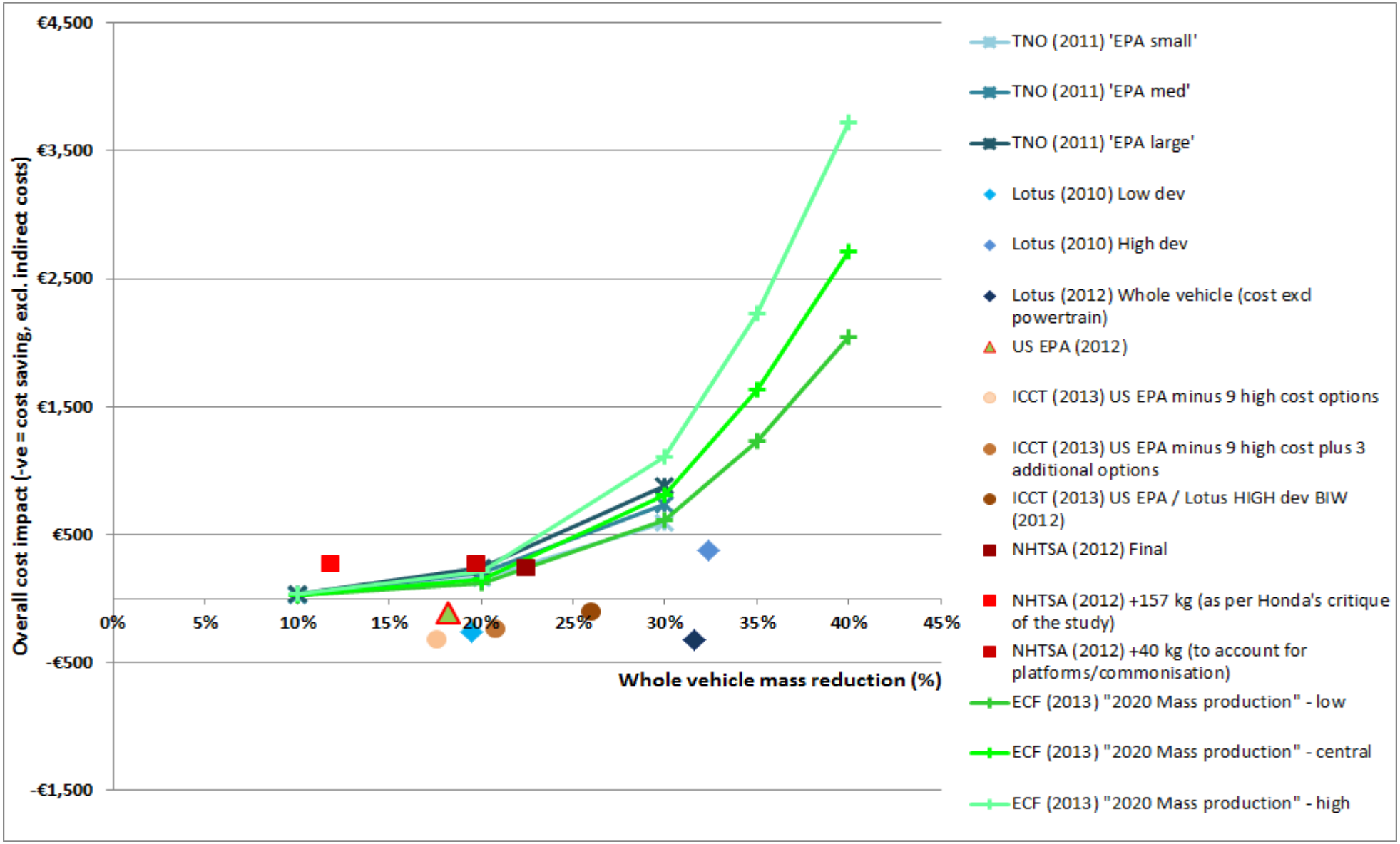
Cost estimates for whole vehicle weight reduction



Stakeholder consultation

- Weight reduction has become a key CO_2 reduction strategy for many OEMs
- Weight reduction is expected to become a greater focus in the future
- Main barrier to weight reduction is cost – including indirect costs
- The new test cycle may not incentivise weight reduction, but changes to test procedures will be important
- Strong disagreement over feasibility and cost of weight reduction (suppliers more optimistic than vehicle manufacturers)
- Strong desire from OEMs to keep a mass based utility parameter for cars
- For vans it is felt essential to continue with a mass-based parameter

Proposed updated costs for weight reduction

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- Based on study analysis, literature review and stakeholder consultation, the following new cost estimates have been developed for weight reduction

Cars

- Medium car 20% weight reduction = **EUR 250**
- Large car 20% weight reduction = **EUR 300**

Vans

- Medium van 20% weight reduction = **EUR 480**
- Large van 20% weight reduction = **EUR 890**

Exploring the impact of footprint versus mass-based utility parameters

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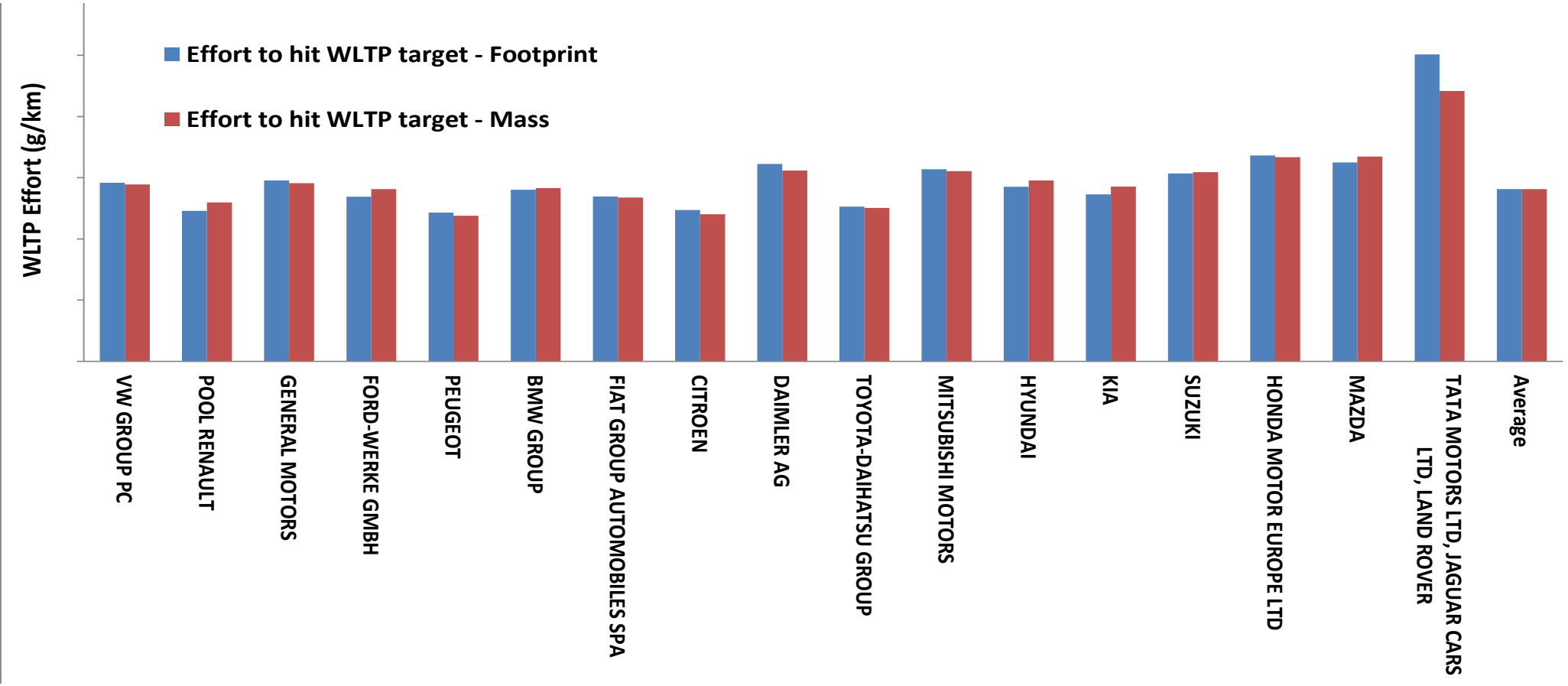
Aim: To assess the impact of footprint versus mass based utility parameters for a hypothetical 2025 target value under the WLTP

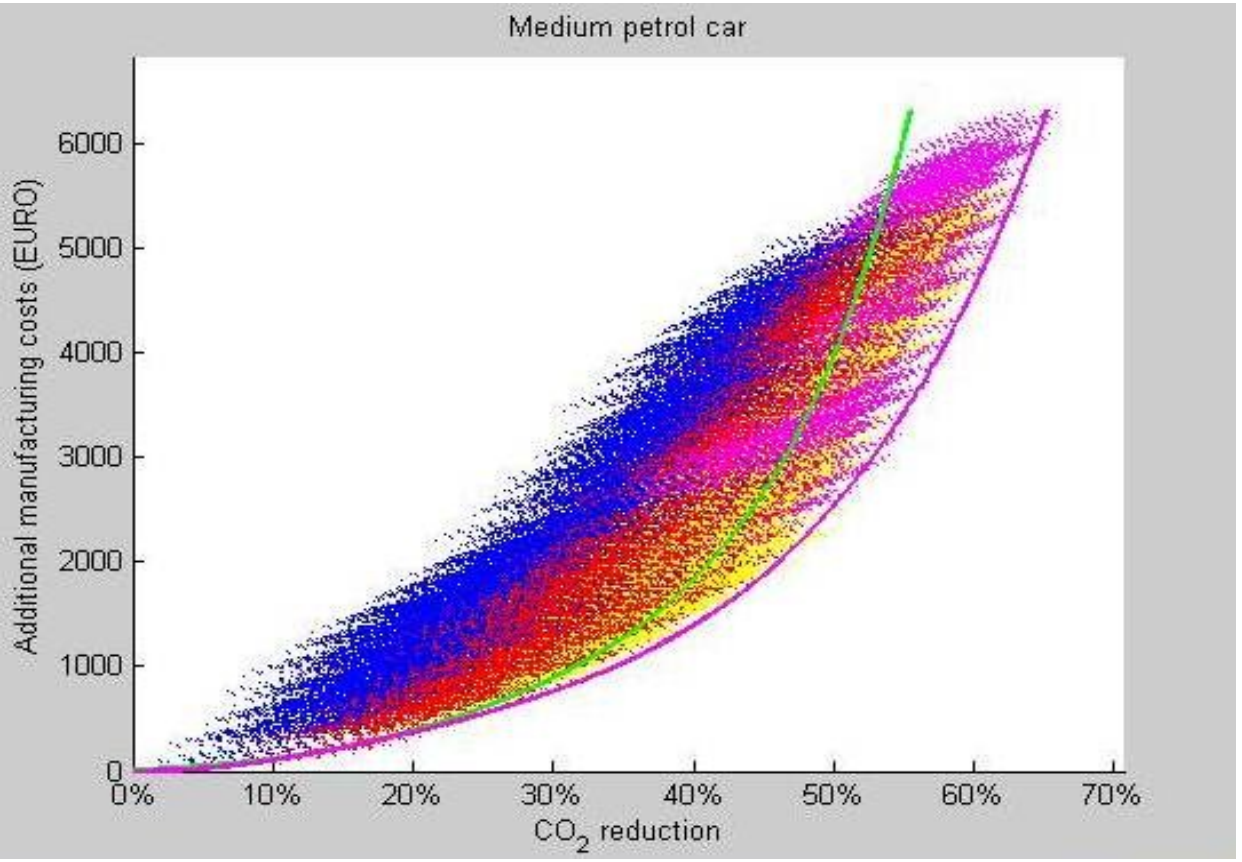
- Existing 2012 EC Car CO_2 monitoring database was 'translated' to WLTP figures.
- Results were compared to a hypothetical 2025 mass-based target with the target slope line adjusted using the same 'equal effort' approach as has been applied between 2015 and 2020.
- Results were also compared to a footprint based target for 2025 calculated to achieve the same overall CO_2 reduction.
- The effort required by each manufacturer to reach the two alternative target lines was calculated.

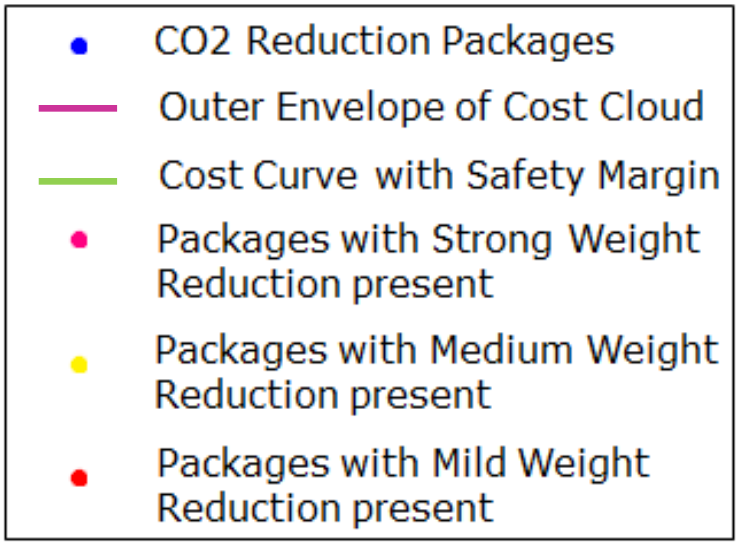
Exploring the impact of footprint versus mass-based utility parameters



- Using footprint as the utility parameter:
  - 7 manufacturers would require less effort to meet the hypothetical 2025 target
  - 10 manufacturers would require more effort to meet the hypothetical 2025 target
- Overall effort is identical, only the distribution amongst OEM poolings is changed

Cost impacts of weight reduction under the WLTP





- Revised WLTP CO_2 emissions reductions for weight reduction and other technologies were combined with revised costs to create new 'cost clouds'.
- Technology packages which include medium weight reduction (yellow) and mild weight reduction (red) are amongst the most cost effective.

Options to ensure weight reduction is as attractive with a mass-based utility parameter

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Rationale:

- If 'mass' is retained as utility parameter for post-2020 targets for cars…
- … to explore qualitatively whether there might be additional options that could be used to ensure that weight reduction is as attractive as other technologies for reducing CO_2 emissions.

Method - three stages:

- Literature review/stakeholder engagement to identify long-list of possible options
- Evaluation of a long-list of possible options against important conditions
- Detailed assessment of a short-list of options.

Options to ensure weight reduction is as attractive with a mass-based utility parameter

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- **Detailed assessment of short-list of options**
  - Weight reduction credits for manufacturers demonstrating a downward mass trend (on the sales-weighted average)
  - Banking of CO_2 emissions reductions allowed where an annual target is exceeded and a downward mass trend is demonstrated (on the sales-weighted average)
  - Linking of targets to mass by setting more stringent targets for heavier vehicles and more lenient targets for smaller vehicles, e.g. by setting a ceiling that affects only the largest vehicles and a floor for smaller vehicles
  - Weight reduction credits (and debits) for vehicles based on their 'density' relative to the overall average 'density' (i.e. mass over footprint)

Evaluation of the selected options against policy criteria

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	Effectiveness in…		Coherence with other elements of Regulation	Efficiency		Equity	
	Incentivising mass reduction	Avoiding perverse incentives		Admin costs	Cost of CO_2 reductions	Across manuf-acturers	Impact on early movers
1. Credits where downward mass trend	✓	?	?	✓	?	?	×
2. Banking where target is exceeded and downward mass trend	✓	?	?	✓	✓	?	×
3. Setting floor (ceiling) that affects only the smallest (largest) vehicles	×	?	?	✓	×	×	✓
4. Downweighting credits (+ debits) for vehicles based on their relative 'density'	?	?	?	✓	✓	✓	✓

Options to ensure weight reduction is as attractive with a mass-based utility parameter

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Findings

- Difficult to see why introducing a mass component in complementary legislation would be better than simply having a strong CO_2 component

- Many potential options considered for amending Regulation – most considered to not meet necessary conditions or be inequitable in some way

- Retained option (weight reduction credits (and debits) for vehicles based on their 'density' relative to the overall average 'density') worth exploring further quantitatively to ensure that it provides the right incentives and avoids perverse incentives

QUESTIONS?

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