Factor of Two: Halving the Fuel Consumption of New U.S. Automobiles by 2035

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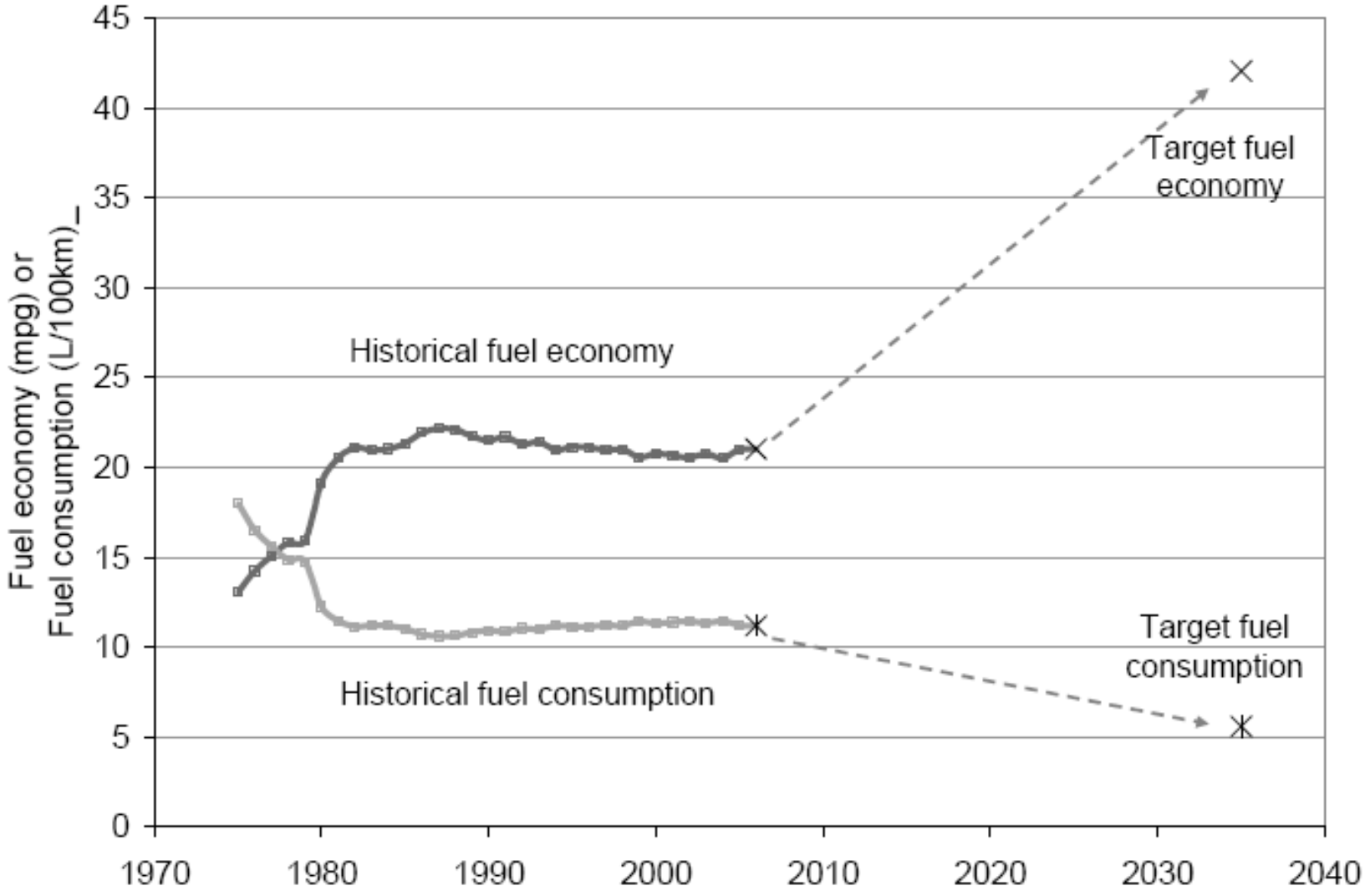
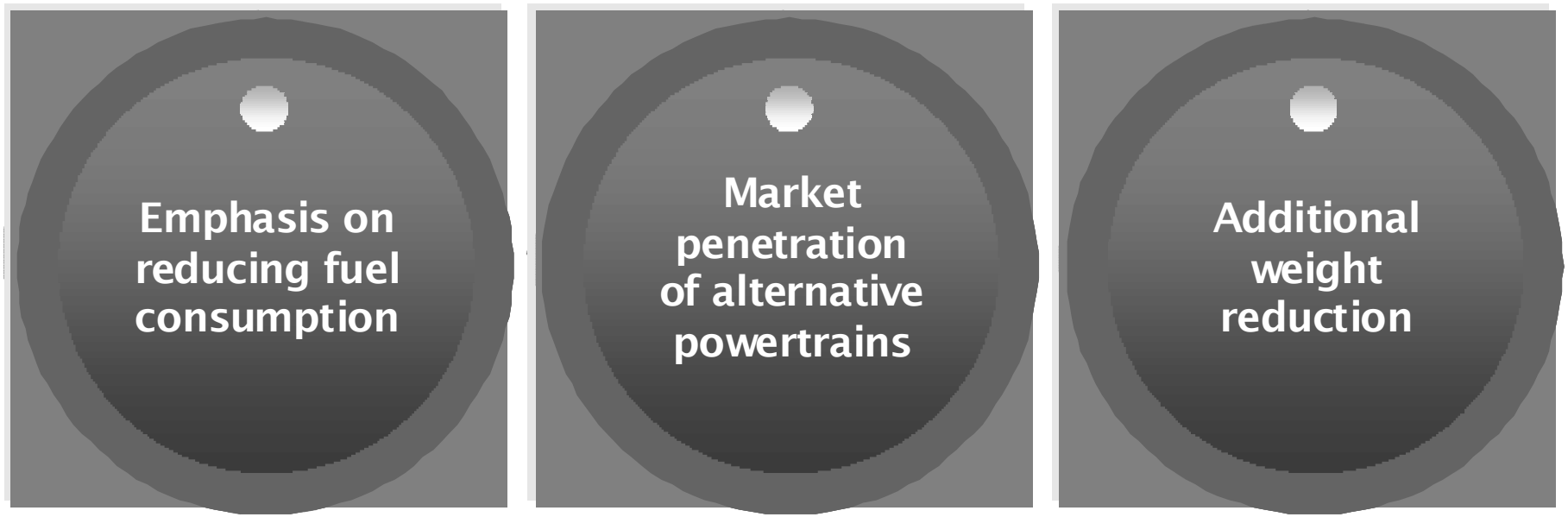
How can we halve fuel consumption?

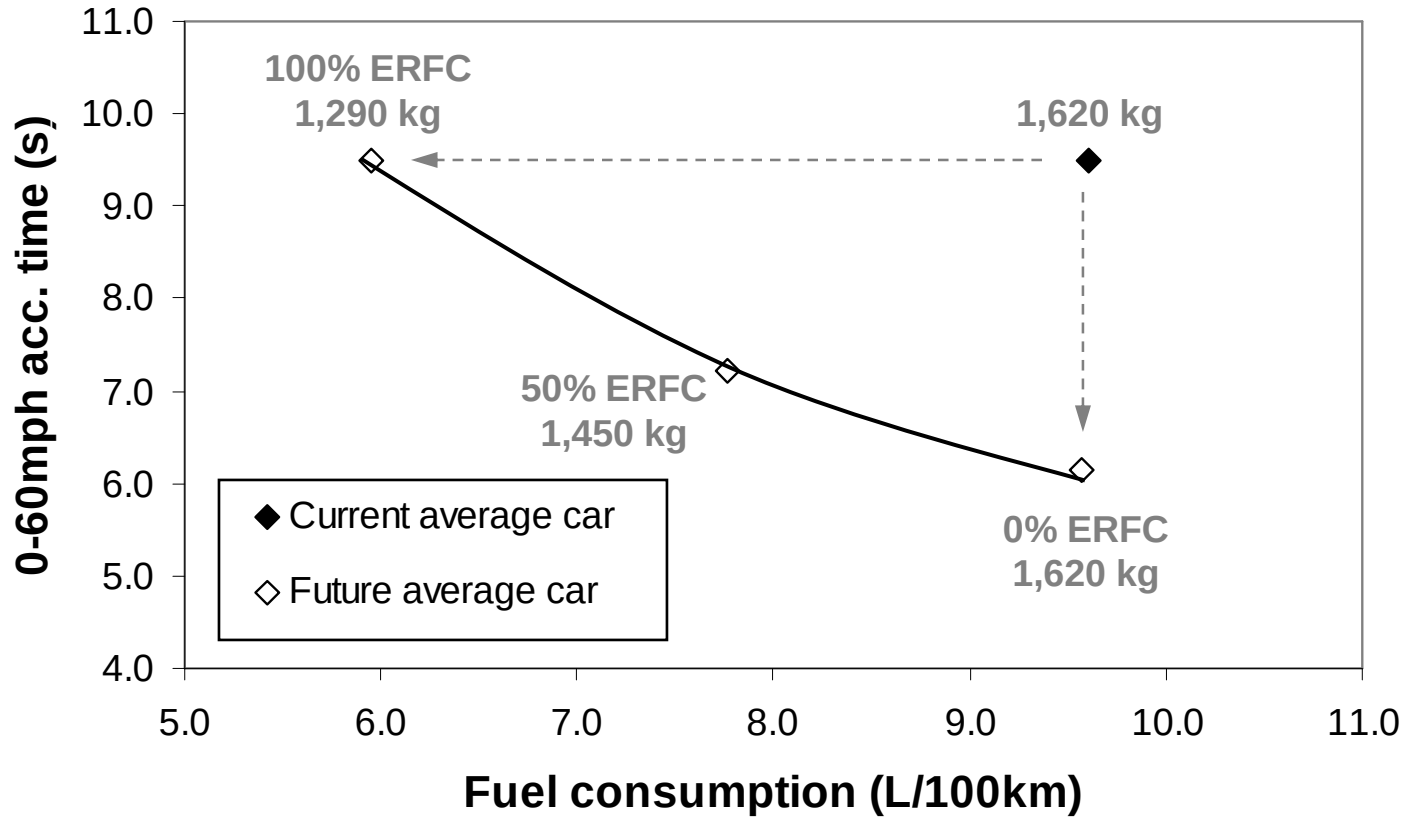


Available technical options

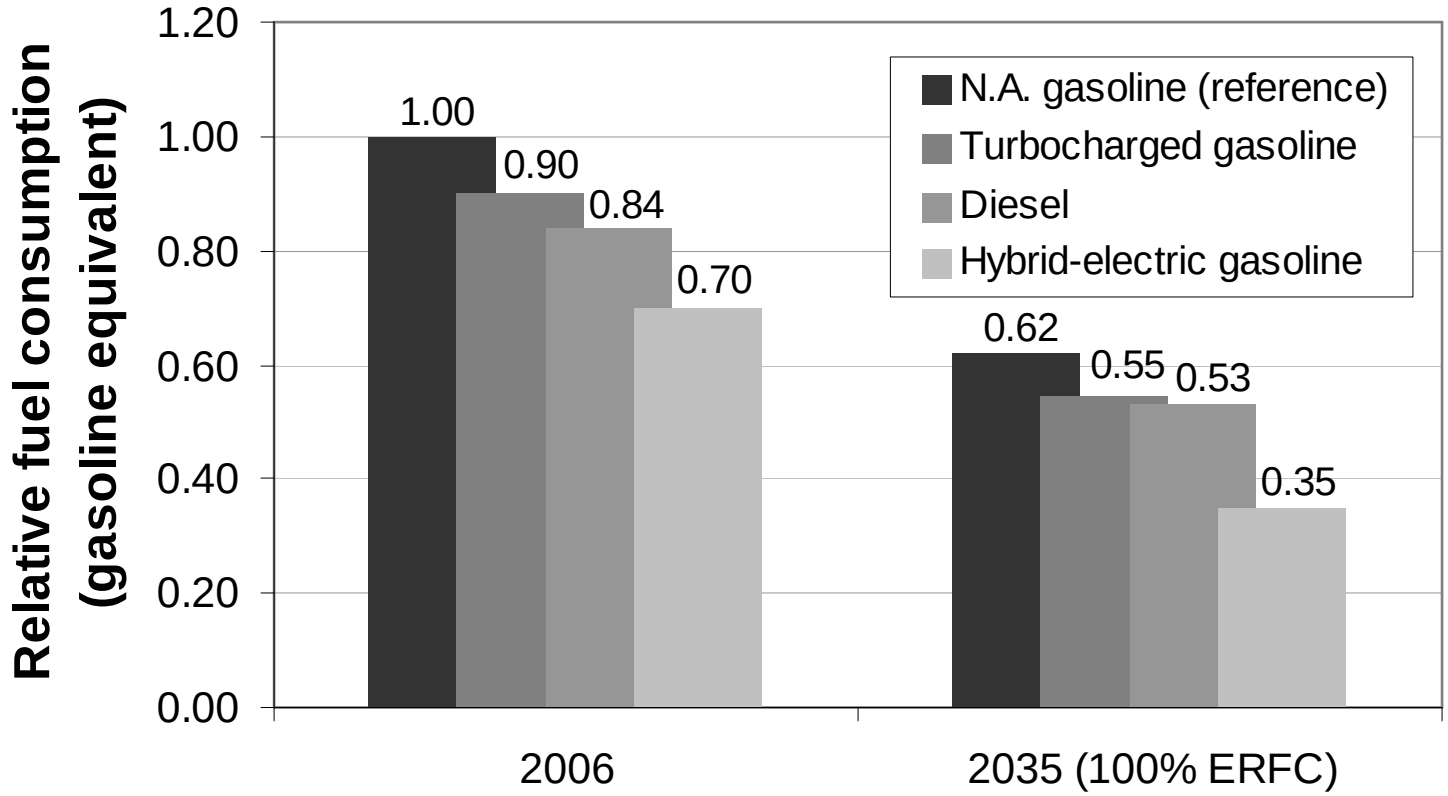


1. Increase emphasis on reducing fuel consumption (ERFC)

$$\%\ ERFC = \frac{\text{Future fuel consumption reduction realized}}{\text{Future fuel consumption reduction possible with constant size and performance}}$$



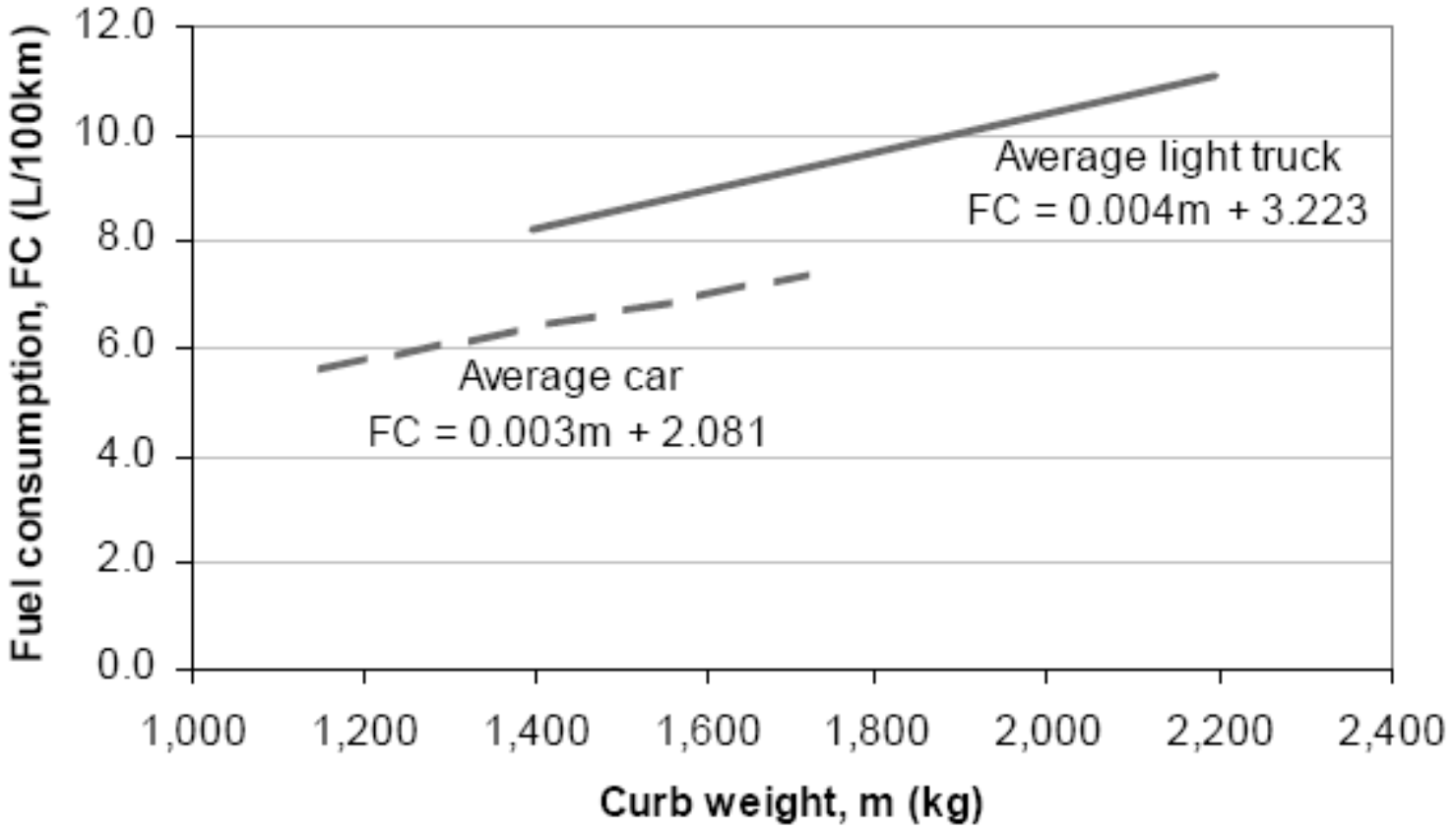
2. Alternative, more efficient powertrains



Data source: Kasseris and Heywood, 2007

- Current market share of alternative powertrains < 5%
- Assume market share of alternative powertrains can go up to 85% by 2035

3. Vehicle weight reduction



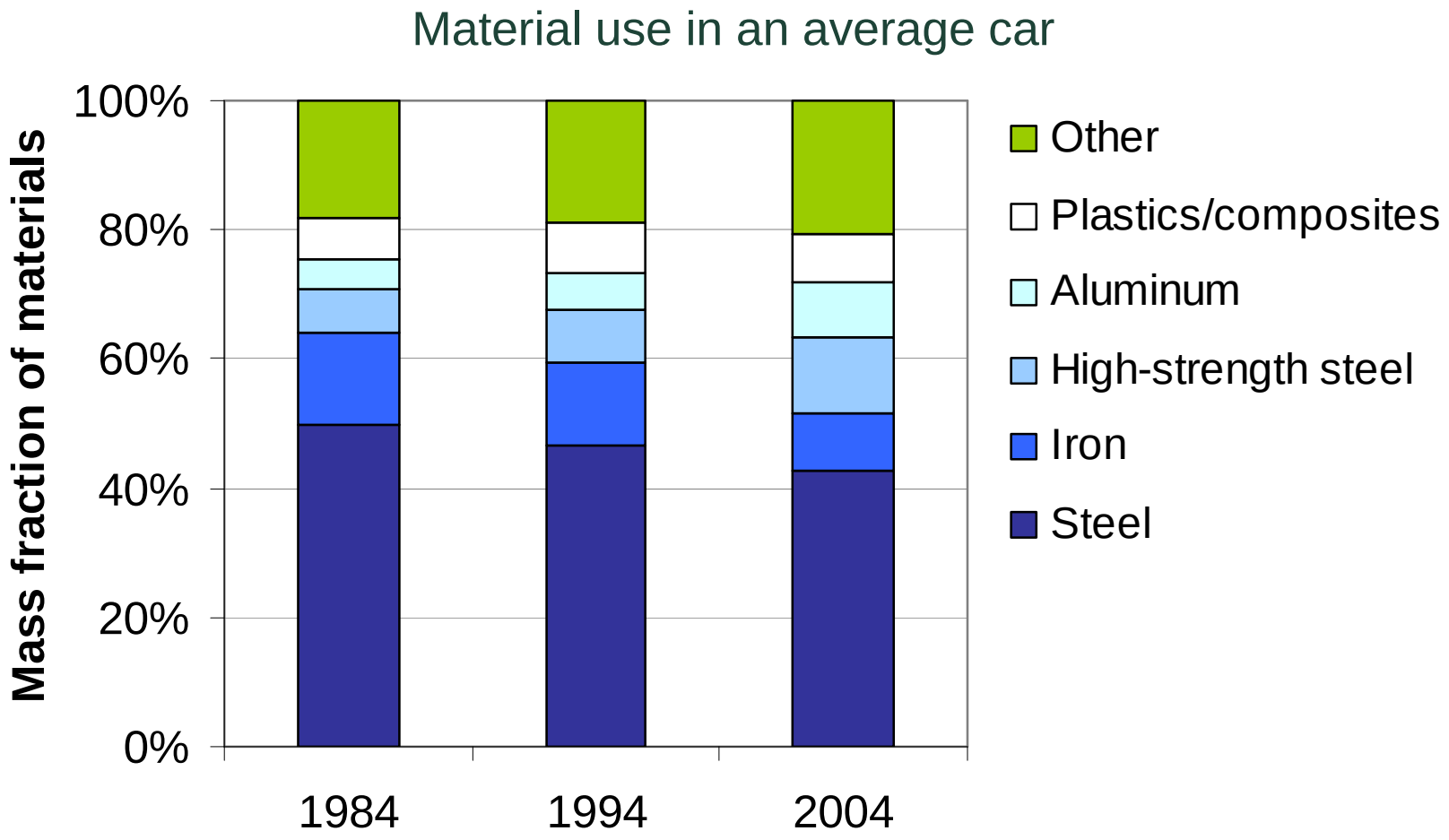
- Assume up to 35% weight reduction can be achieved, through a combination of lightweight material substitution, vehicle redesign, and downsizing.

Results: Illustrative scenarios

Scenario	INPUTS			OUTPUTS (vehicle characteristics)					
	Degree of each option			2035 average new car			2035 average new light truck		
	% ERFC	% alternative powertrain	% weight reduction from today	0-60 mph acc. time	Fuel consumption , L/100km	Vehicle weight	0-60 mph acc. time	Fuel consumption, L/100km	Vehicle weight
2006 values	--	5%	--	9.5s	9.6	1,616 kg	9.9s	12.8	2,137 kg
I	100%	34%	35%	9.4s	4.8	1,054 kg	9.8s	6.4	1,394 kg
II	96%	85%	19%	9.2s	4.8	1,318 kg	9.6s	6.4	1,743 kg
III	61%	85%	35%	7.6s	4.9	1,060 kg	8.4s	6.3	1,402 kg

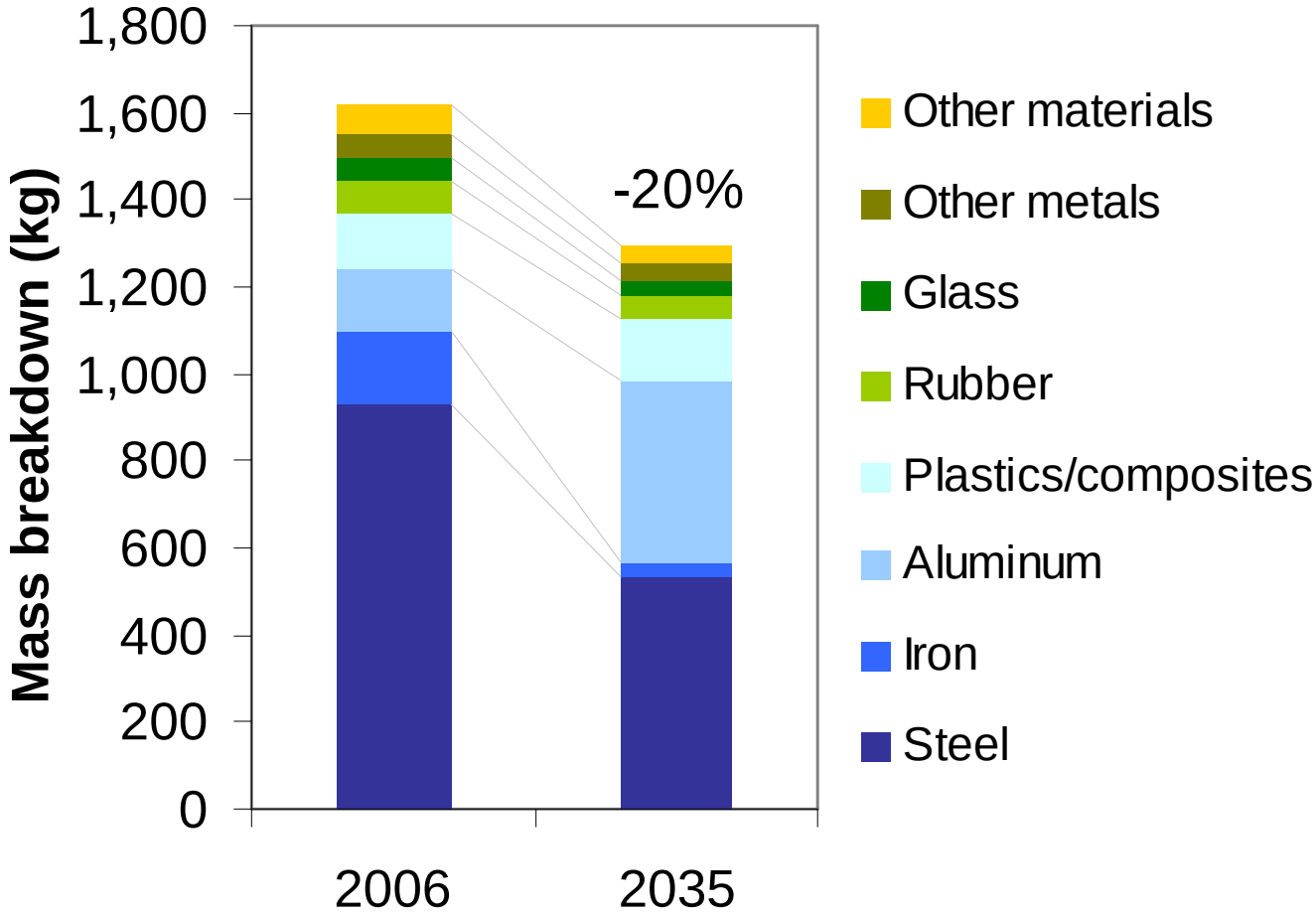
Historical trend

Use of lighter-weight materials in vehicles increasing



Source: US DOE, 2007

Material composition of a new car after lightweight material substitution

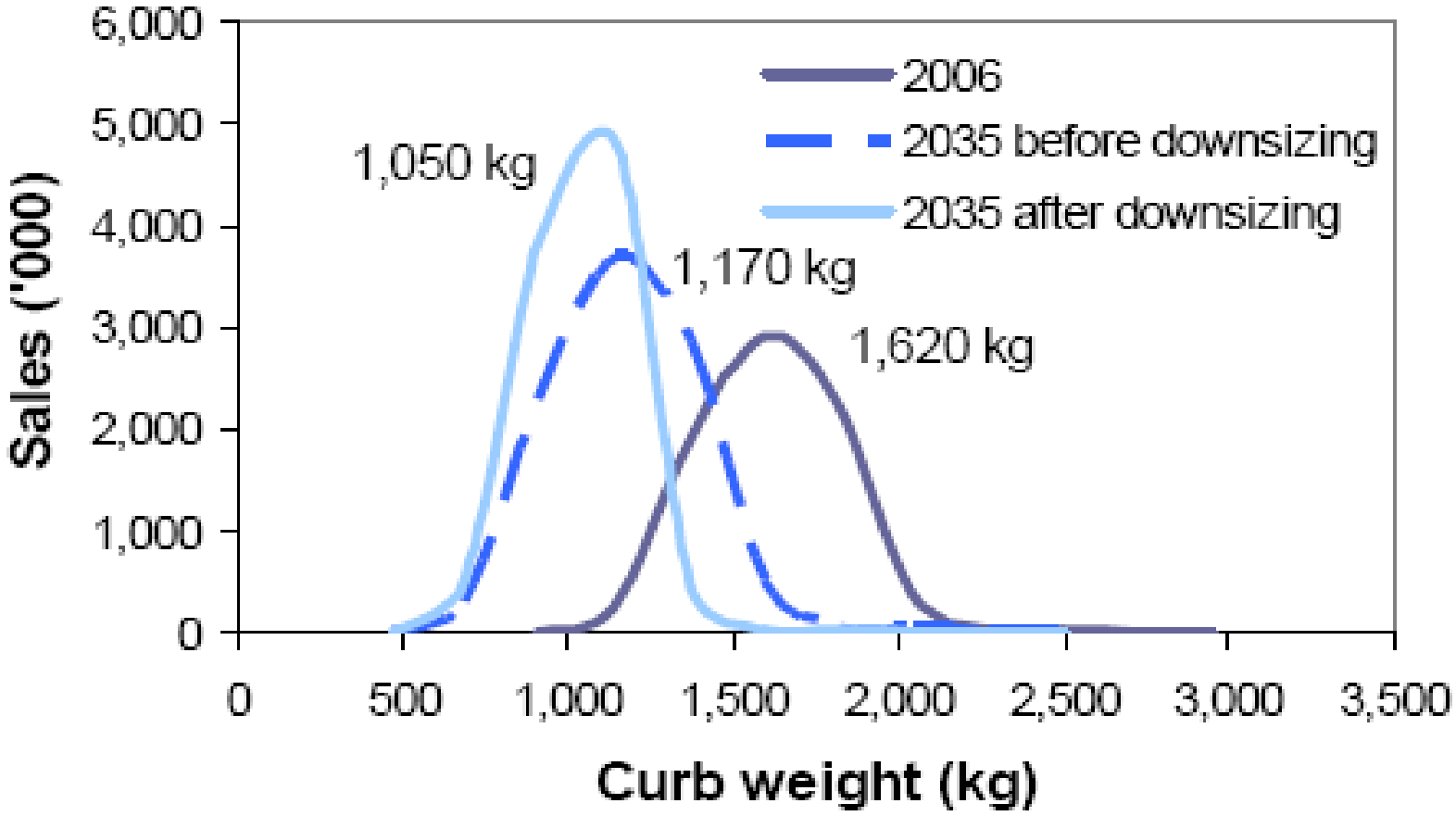


From literature

Cost of material substitution depends on many factors

Lightweight vehicle / component	Incremental OEM cost	Weight reduction	US$ per kg reduction	Volume per yr	Source
General lightweight vehicle	-	-	**2.20 to 3.70**	-	NRC 2002
High strength steel (HSS)-intensive					
Front end	-$13	11 kg	**-1.20**	-	Roth 2006
SUV frame	-	(-23%)	**0.68**	220,000	Altair 2003
Body-in-white	-$32-52	52-67 kg	**-1.00 to -0.47**	225,000	Shaw 2002
Aluminum-intensive					
Vehicle	$661	346 kg	**1.91**	200,000	Stodolsky 1995
Unibody	$537	138 kg	**3.88**	500,000	Han 1994
Polymer composites-intensive					
Body (glass fiber reinforced)	$400	127 kg	**3.16**	100,000	Kang 1998
Body (glass fiber-thermoset)	$930	68 kg	**13.68**	250,000	Dieffenbach ‘96
Body (carbon fiber reinforced)	-	-	**2.20 to 8.82**	-	Das 2001
Body (carbon fiber reinforced)	$900	196 kg	**4.59**	100,000	Kang 1998
Body (carbon fiber-thermoset)	$728	114 kg	**6.39**	100,000	Mascarin 1995
Vehicle (carbon fiber)	$2,926	444 kg	**6.59**	200,000	Stodolsky 1995
Body (carbon fiber-thermoplastic)	$1,140	145 kg	**7.86**	250,000	Dieffenbach ‘96

Vehicle sales distribution before and after downsizing



Safety concerns

- Lighter vehicles can be designed to be safe
  - Reinforce the structural stiffness of the vehicle at critical points, side airbags, crumple zones
- Societal vs. individual safety
  - A heavier vehicle poses less risk to its occupants
  - A lighter vehicle poses less risk to other road users

4/5 stars, like many family-sized cars in European NCAP

★★★★

4/5 stars in US NHTSA crash and rollover ratings

Questions?

Report available at:

- http://web.mit.edu/sloan-auto-lab/research/beforeh2