Committee on Climate Change

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Sustainable transport: challenges for materials

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King Review of Low Carbon Cars

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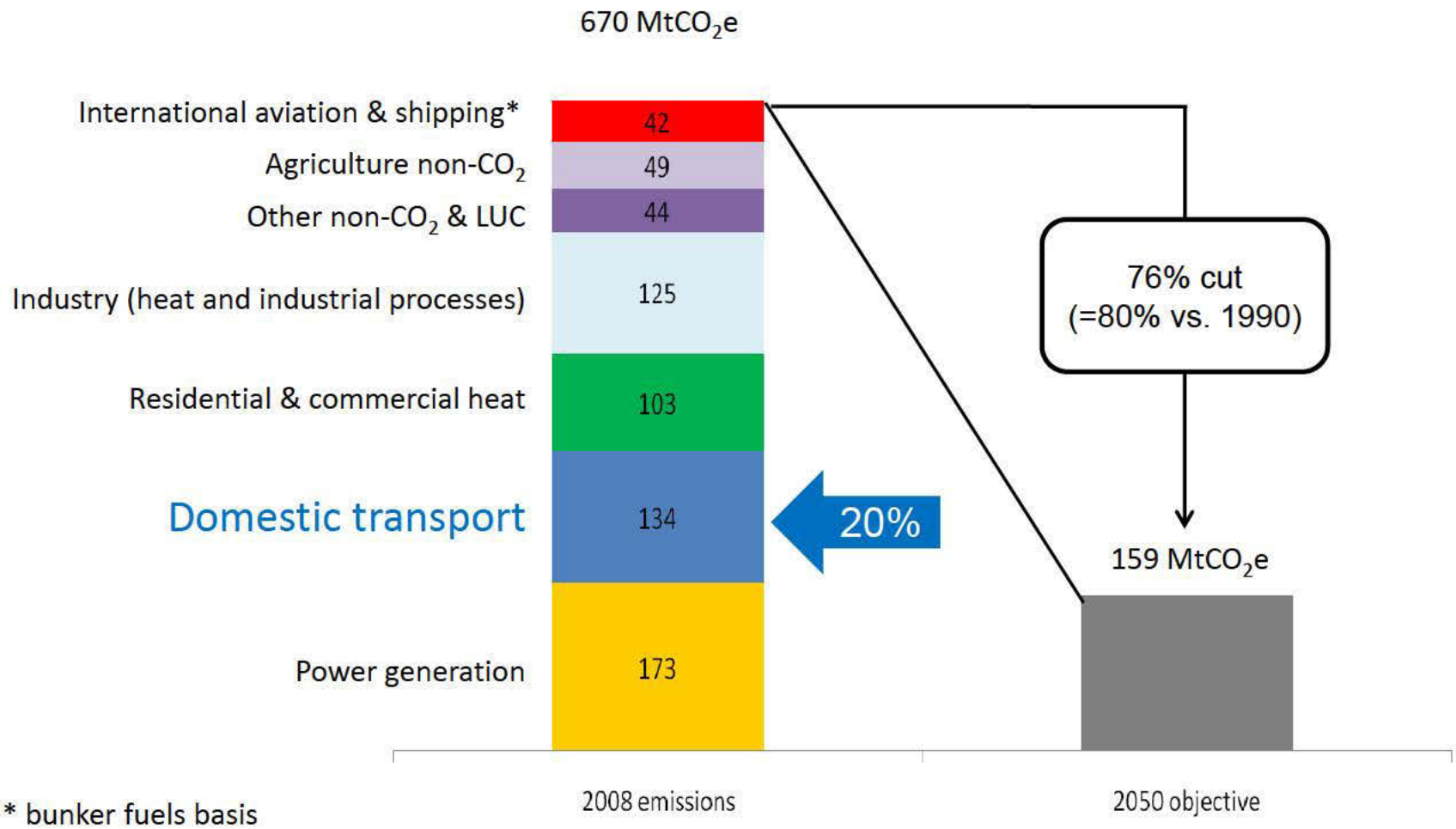
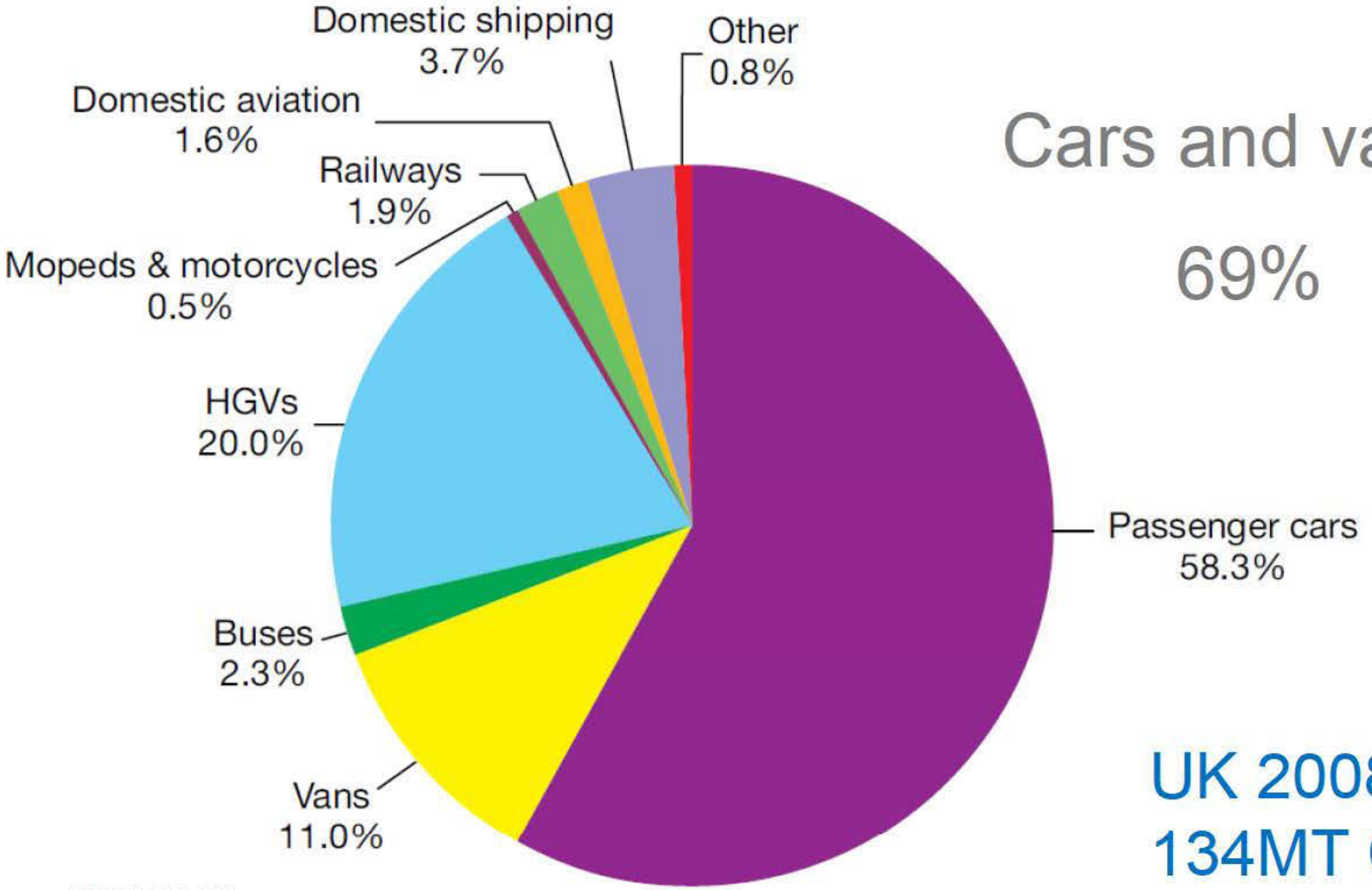
- The scale of the CO_2 emissions reduction challenge
- Reducing emissions
- Opportunities for materials

The UK's 2050 target



* bunker fuels basis

The UK transport emissions challenge: cars



Cars and vans:

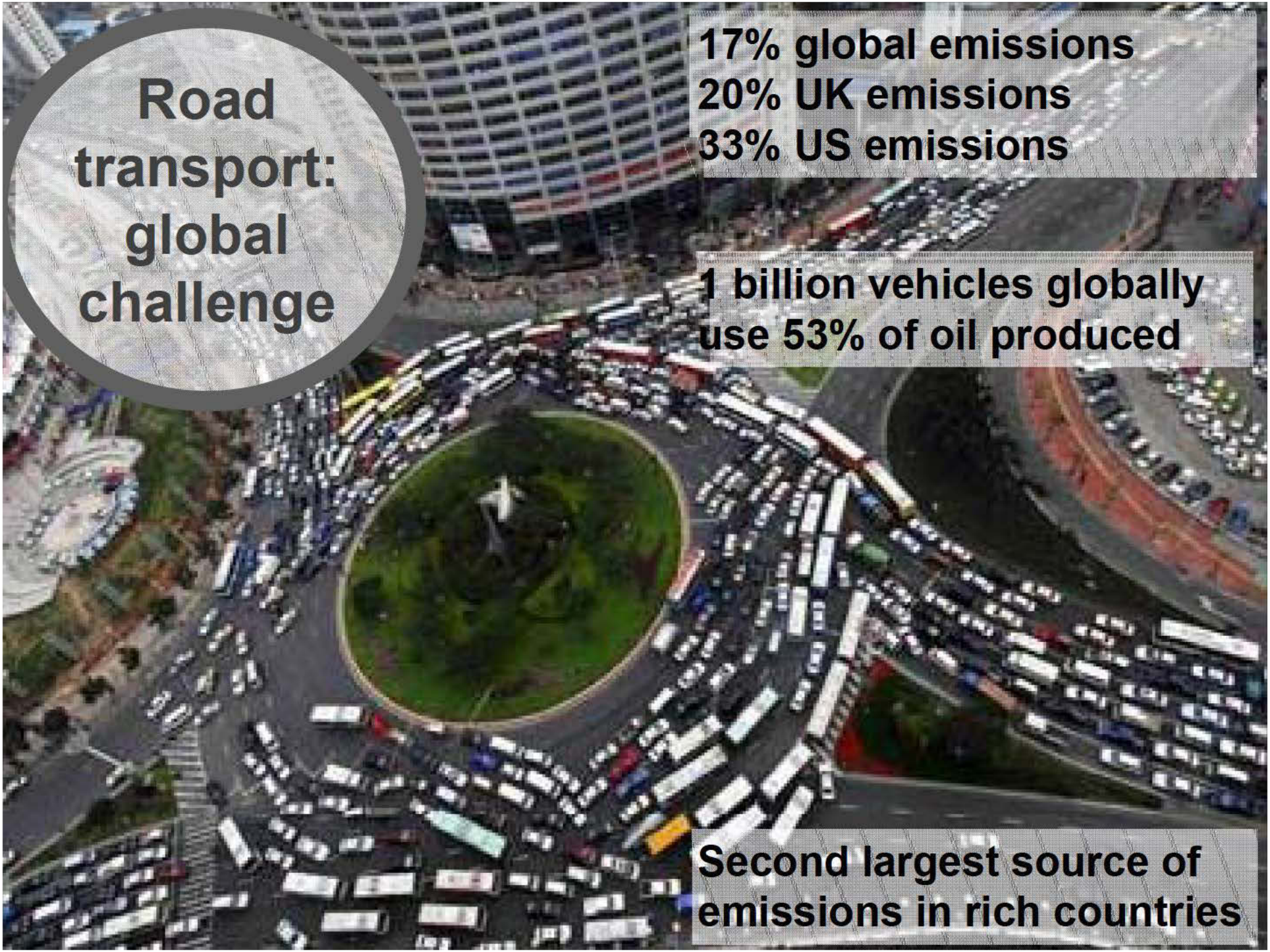
69%

UK 2008
134MT CO_2

Source: DfT 2009

UK: 90% reduction for land transport

- 80% reduction in GHG emissions from 1990 levels by 2050
- At least a 90% reduction in g/km for cars and vans by 2050
  - Increasing distance driven
  - Increasing number of vehicles (x1.2 by 2050)
  - Large vehicle (trucks and coaches) options more difficult
  - AND – some other sectors have greater challenges: eg aviation
- Average car today: 150g/km 2050: 15g/km


Road transport: global challenge
17% global emissions
20% UK emissions
33% US emissions
1 billion vehicles globally use 53% of oil produced
Second largest source of emissions in rich countries


2010
6.5 billion people
850 million cars
2050
9 billion people
3 billion cars?

The emissions reduction challenge: cars

- UK 90% reduction: 150g/km down to 15g/km
- Globally 50% reduction in emissions
  - But 2 to 3 fold increase in the number of cars
- Globally 75-85% reduction
- Cars with emissions of less than 30 - 40g/km

Reducing Emissions

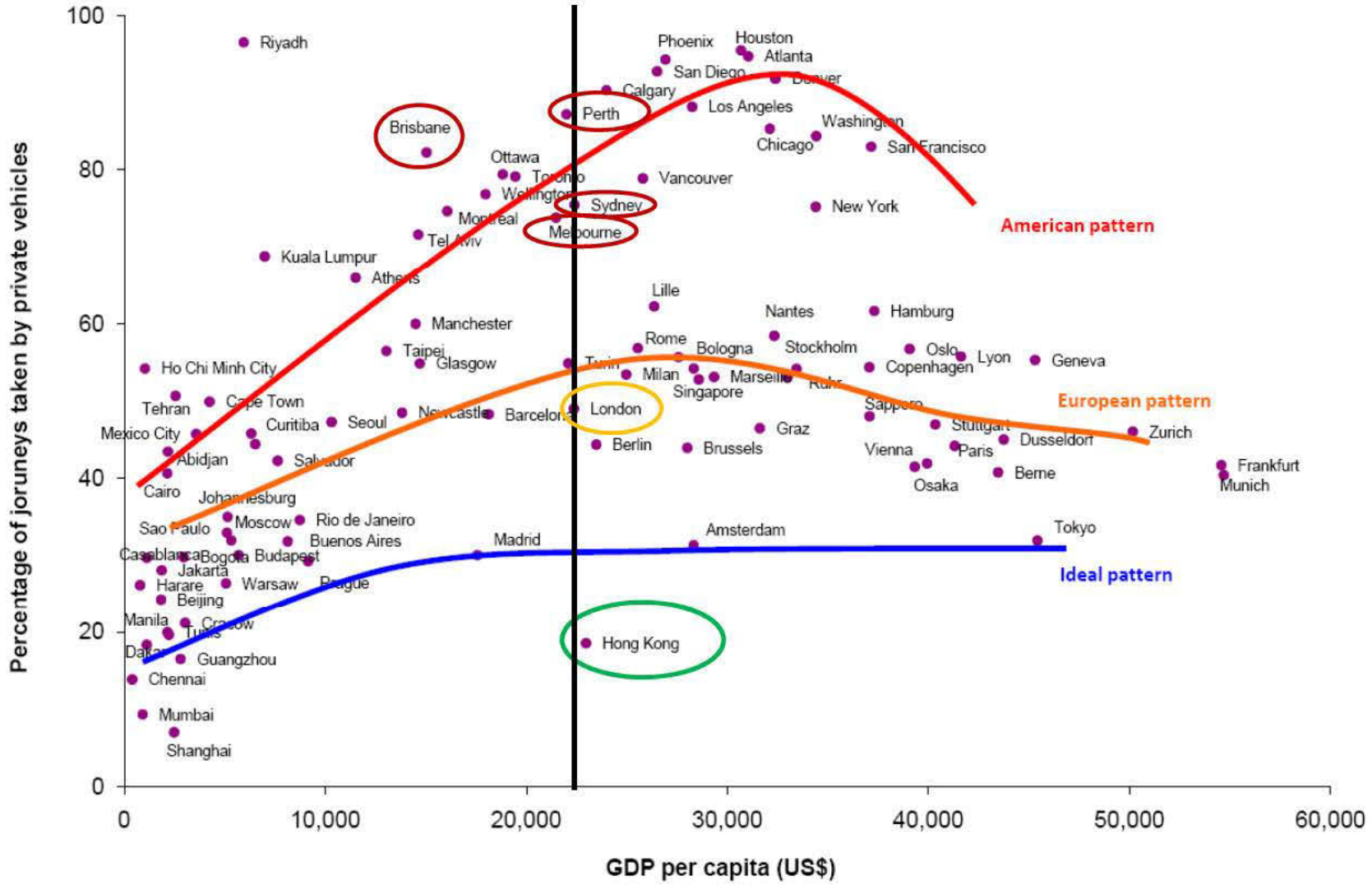
- **Efficient People**
- **Efficient Cities**
- **Efficient Cars**

Efficient people: smart behaviour

KING REVIEW

- Driver behaviour has a big effect on CO_2 from road transport
  - vehicle choice: best in class 25 - 40%
  - switch to a smaller car: more than 50%
  - eco driving: up to 15%
  - reduce/enforce speed limits: 70mph → 50mph: 20% saving
  - reduced marginal car use
  - car clubs, car sharing
  - modal shift - public transport…
- Behaviour change: potential 50% reduction in emissions
  - and it saves money
- Hard to achieve because…
  - environmental awareness/action in transport lags other sectors
  - powerful cars are symbols of status
  - heavy discounting of future fuel cost savings
  - the rebound effect
  - means are unappealing: speed cameras, higher taxes, parking and circulation restrictions, time, distance, place and occupancy-based road charging...
  - driving where and when I like is a 'right'

Efficient cities: use of public transport

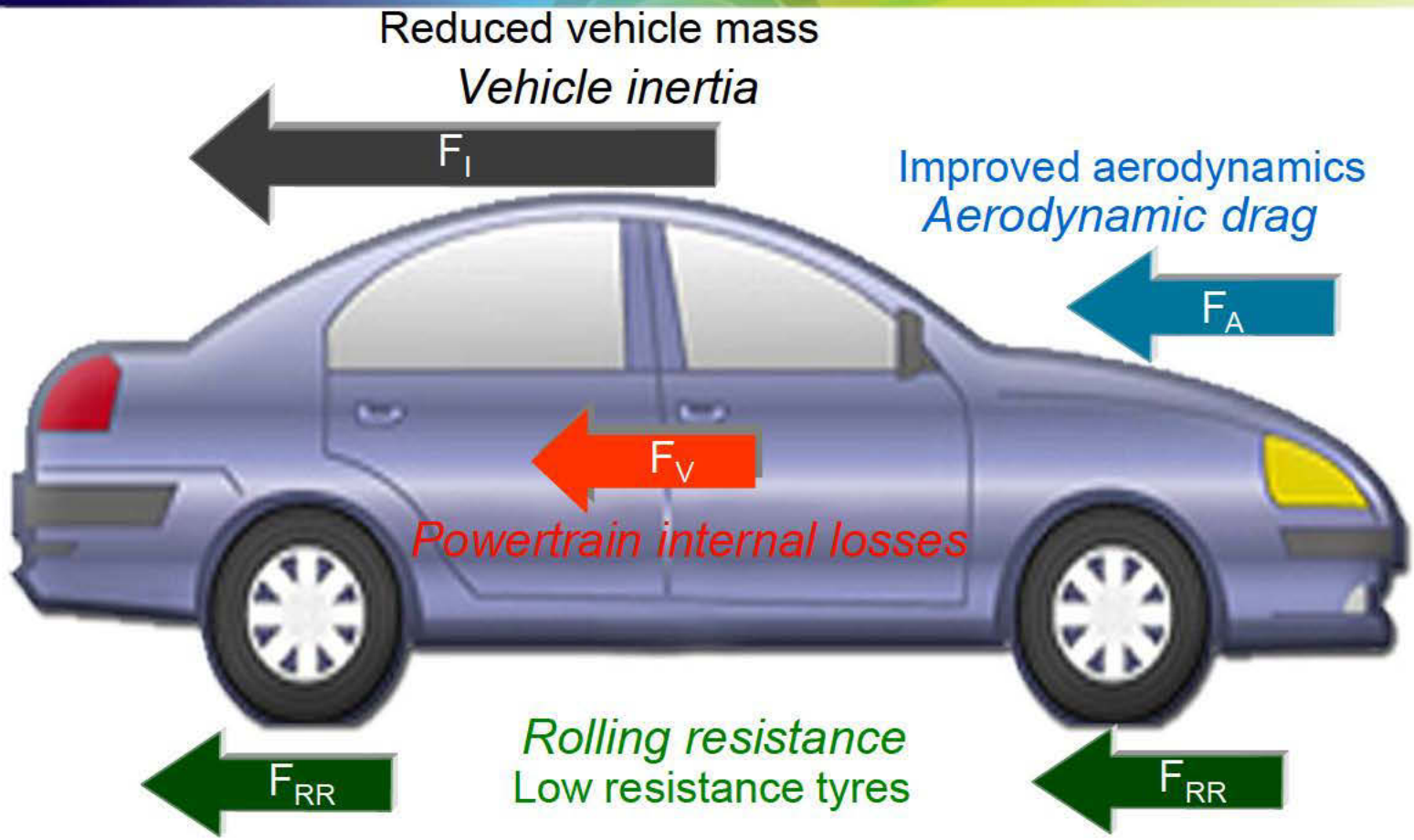


Source: IEA (2008) and International Association of Public Transport (2006).

Efficient cars
available technology can improve ICE vehicle efficiency by 50%

Source: King Review HMT 2007, 2008

Cars: 30 - 50% savings in the short term



Improved efficiency of internal systems:

electronics, entertainment, air conditioning

Key opportunities for materials

- Lightweighting
- Low friction
  - Lubrication; low rolling resistance tyres; intelligent surfaces
- New battery and fuel cell materials and manufacture
- New fuels
  - Hydrogen storage

Lightweighting: reducing inertia

- A benefit for stop-start driving
- Typically 0.7% efficiency improvement for 1% mass reduction
- Typically up to 10% efficiency improvement
- Claims for 38% mass reduction delivering 33% efficiency improvement on a large car
- Polymer composites, aluminium and magnesium alloys, MMCs, plastics, metal and plastic foams…and RECYCLING
- BMW 3i and 8i battery electric and plug in hybrid vehicles

Lightweighting: BMW 8i and 3i

- Al alloy chassis and carbon fibre composite body

New battery materials and manufacture

- Petrol: 13kWhr per kg; Li-ion: 0.16 -0.2kWhr per kg
- 25kWhr Li-ion battery - over 150kg
- Increased energy and power density
- New chemistries and structures
- Nanostructured Li-ion cathodes; Li-organic; Li-air; $ALCF_x$; Zn-air…

New fuels

- Biofuels and synthetic fuels
- Hydrogen storage
- Solid hydrogen: Cella Energy
  - NH_3BH_3, ammonia borane, in a polystyrene nanoscaffold
  - 6wt% hydrogen
  - Micron scale fibres and particles
  - Hydrogen released below 80°C
  - Petrol: 13kWhr/kg
  - Hydrogen: 39kWhr/kg
  - 6wt%: 2kWhr/kg

A huge challenge

- Cars with emissions of less than 30 - 40g/km
- Enormous opportunities for advances in materials
- Innovation and new companies emerging in the UK
  - Cella Energy
  - Intelligent Energy
  - Gordon Murray Design
  - Zytek
  - Drayson Racing
  - ……..