"When I turn on the TV, I see wall-to-wall Humvees, and I’m proud," said Sam Bernstein from Marin County, who drives a Hummer H2. "They're not out there in Audi A4's," he said of the troops. "I'm proud of my country, and I'm proud to be driving a product that is making a significant contribution."

Website:  Education for Peace in Iraq Center

“The H2 is a gas guzzler. So while our brothers and sisters are off in the Middle East risking their lives to secure America’s fossil fuel future, H2 drivers are pissing away our “spoils of victory” during each trip to the grocery store.

Website:  Fuck you and your H2
Economic significance of transport

- UK business invests £85bn p.a. in supply chains.
- 3,400 people die on the roads p.a.
- Road congestion costs €20bn p.a.* (1.5% GDP)
- Transport industry a major source of wealth/employment
- ¾ of households own at least one car – largest single investment after the house
- Travel can take ~30% of someone’s active hours

*TBI estimate

Trends in energy use
(excluding international travel)

UK energy use up 6% in last decade
Transport use, excluding international air routes, up 15%
Transport’s share up 33% → 35%
Transport’s share of petroleum up 54% → 65%
Oil reserves (billion barrels)

<table>
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<tr>
<th>Country</th>
<th>OGj</th>
<th>WO</th>
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<td>59</td>
<td>Algeria</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>

OGJ = Oil & Gas Journal, WO = World Oil estimates  * primarily oil shale

Oil exhaustion scenarios

Colin Campbell, 1996
http://www.oilcrisis.com/midpoint.htm
Jean Lehemèrè
http://www.oilcrisis.com/midpoint.htm
Climate change

![Graphs and charts showing climate change trends and projections.]

Reduction in fuel use

Assumes principle of “equal pain”

- To achieve 550 ppm CO\textsubscript{2} requires 55% reduction
- To achieve 450 ppm CO\textsubscript{2} requires 79% reduction

Source: Leeds ITS
Global options for reducing CO₂

• Equal reductions all round?
  - Maintaining present 1st / 3rd world imbalance
• Contraction and convergence?
• Equal pain between sectors?
• Transport gets all the oil and ESI goes renewable?

Reducing CO₂ in the transport sector

• Increasing efficiency of transport systems to use significantly less fuel per passenger-km or tonne-km
• Reducing the overall amount of personal travel and movement of goods
• Transferring passengers and freight from high-consumption modes (roads & air?) to low-consumption modes (rail?)
• Obtaining energy from non-carbon sources
It can be argued that TGV cut CO₂ in France, due to nuclear generation.
Would the same be true in Britain?

Source: Berlioz & Leboeuf (1986)

An alternative view

“Norway cannot treat electricity as carbon-free. There is only a certain amount of hydro-power and, if it is not used for a high-speed line, it could be exported to Germany to replace the burning of lignite in conventional power stations.”

Are Wormnes, Norwegian Centre for Transport Research
Non-carbon electricity

Renewables 3%
Other 2%
Nuclear 26%
Coal 34%
Gas 35%

Does it matter where energy comes from?

Energy use of UK electric trains

Class 373 Eurostar
Class 390 Pendolino 9-car
Class 90 + 9 + DVT
Class 390 Pendolino 11-car
Class 458 SWT
Class 460 Gatwick Express
Class 91 IC225
Class 357 Electrostar

Energy kWh/seat-km
Fuel consumption of UK diesel trains

- Class 221 Voyager
- Class 222 Meridian
- Class 180 Adelante
- Class 43 HST
- Class 170 Turbostar

Fuel consumption: litres/100 seat-km

CO₂ emissions of electric and diesel trains

- Class 221 Voyager
- Class 222 Meridian
- Class 180 Adelante
- Class 373 Eurostar
- Class 43 HST
- Class 170 Turbostar
- Class 390 Pendolino 9-car
- Class 90 + 9 + DVT
- Class 390 Pendolino 11-car
- Class 458 SWT
- Class 460 Gatwick Express
- Class 91 IC225
- Class 357 Electrostar

CO₂ emissions: g/seat-km
Load factor

- Most vehicles (trains, cars, planes, ships) use much the same amount of fuel however many people are travelling
- Average load factor on trains 30%
  - varies between 20% and 50% depending on TOC
  - full leaving London, empty north of Lancaster
- Average number of people in a car 1.8
  - What is the load factor when a parent is taking a child to school by car?

Load factors

Train load factor 2005-06

NB: TOCs 11 and 17 are misrepresented due to other sources of passengers
On average buses carry 9 passengers and achieve 5.6 miles/gallon

Carbon emissions of transport

Plane Lon - Mcr
Plane Lon - Edi
Plane Cardiff - N'cstle
Private car
Class 221
Single deck bus
Class 222
Class 180
Class 373 Eurostar
Double deck bus
Class 170
Class 43 HST
Class 458
Class 357 Electrostar
Class 390 Pendolino
Class 91 IC 225
Megabus

Full bar = 2007
Blue bar = 2017
### Car fuel consumption

Average of new cars, excluding SUVs

![Graph showing fuel consumption over years](image)

Source: DfT

### Non-carbon fuel

- Requires widespread planting of biomass crops
  - competing with food
  - destruction of amenity

- Environmental impact
  - High water demand
  - Possible fertiliser use
  - Voluminous by-product disposal
Hydrogen fuel cells

- Are hydrogen vehicles a way of reducing global warming . . . or insulating the USA from the reality of the Middle East?

- Where will the hydrogen come from?
  - Hydrocarbons?
  - Electrolysis?

Flying at 0.01 metres and 500 km/h
Power demand of 10-car maglev

Power drawn from grid when accelerating

Airbus consumption vs. sector length
A321-100 single class seating

Source: Airbus
A high-speed line?

For
- Rail uses less energy per seat
- Rail uses electricity not liquid fuel
- Rail emissions are at ground level

Against
- Present traffic levels could not fill a high-speed line
- Planes in UK operate at higher load factors

Diversity of destinations
Modal split of available seats
Edinburgh - English airports

NB: Figures are approximate and refer to 07:00 – 17:00
Estimated roads figure refers to available infrastructure capacity

Commuting by bus
Commuting by car

Commuting by HS train & car
Air – rail modal shift  Scotland - London

• HS rail is always less environmentally damaging than air
  - Particularly if it uses non-carbon electricity
  - Measured on CO₂ emissions per seat

• Air – rail substitution by itself would not provide sufficient passengers for a HS line
  - It would be almost impossible to prevent a new HS line creating environmentally damaging travel growth (e.g. commuting)
  - Transfer of passengers from conventional rail to HS rail is environmentally damaging, unless using non-carbon energy
  - A privately financed HS line is only likely to be viable if operators have a free hand to maximise travel growth

• Net effect of a new HS line or Maglev could be to increase overall CO₂ emissions, despite transfer from air to rail

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passengers</th>
<th>Power</th>
<th>Speed</th>
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<tbody>
<tr>
<td>Ferry</td>
<td>2000 (with cars)</td>
<td>50,000 kW, 50 km/h</td>
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<tr>
<td>Train</td>
<td>500</td>
<td>4,000 kW, 200 km/h</td>
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<tr>
<td>Plane</td>
<td>200</td>
<td>20,000 kW, 800 km/h</td>
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</tbody>
</table>
London – Hyderabad: options

- Plane (A380, B747)
- The Orient Express with sleeping/dining cars
- Ocean liner
- Overland bus/train (with hotel stops)

Conclusions

- Travel, other than on foot or by bike, is environmentally undesirable
- Operating full vehicles is generally more important than the vehicle type
- Air travel will always be bad for the environment
- But the alternatives can be worse!