Institution of Mechanical Engineers
High Speed Rail Developments
21 April 2004

Environmental impact of high-speed rail

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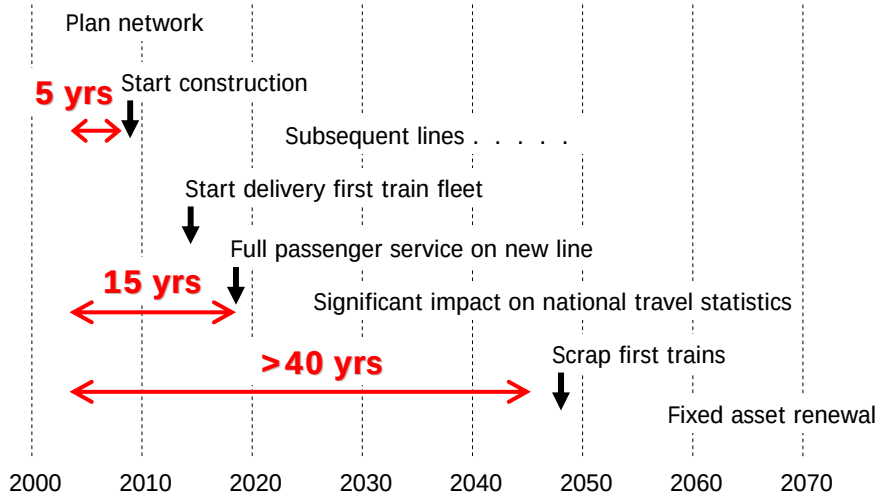
Agenda

- The environmental background
  - Energy supply
  - Environmental issues
- Environmental impact
  - High Speed Rail
  - The competition
- Is there an environmental argument for new high-speed lines ?

NB: Noise is covered in the subsequent paper, so is not included here

Timescale for a new HS line ?

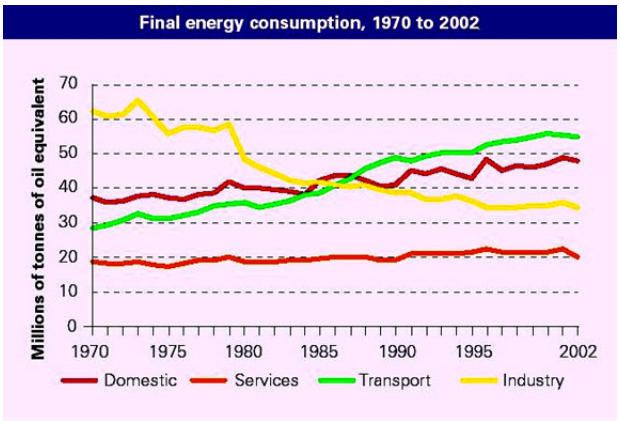


What else may happen in 40 years ?

- Reduced oil reserves
  - Increase in price of energy
- Global warming starts to bite
  - Serious Government action to reduce energy use
- Continued improvement in car and aircraft fuel efficiency
- Reduction in aircraft noise
  - Competition for high-speed rail

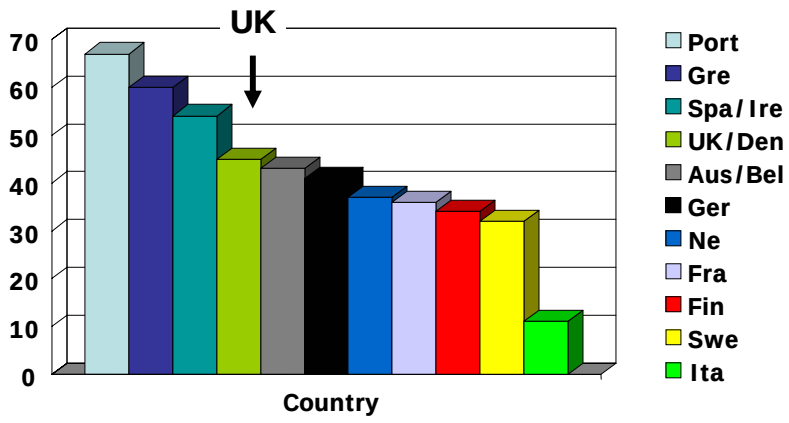
Availability of oil reserves

Trends in energy use



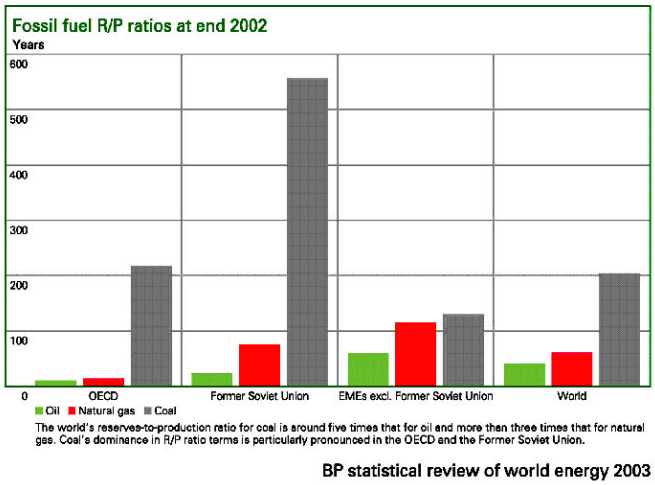
UK energy use up 6% in last decade
Transport use up 15%
Transport's share up 33% → 35%
Transport's share of petroleum up 54% → 65%

Oil dependence in Europe



Source: David Bayliss

Reserves/production ratios



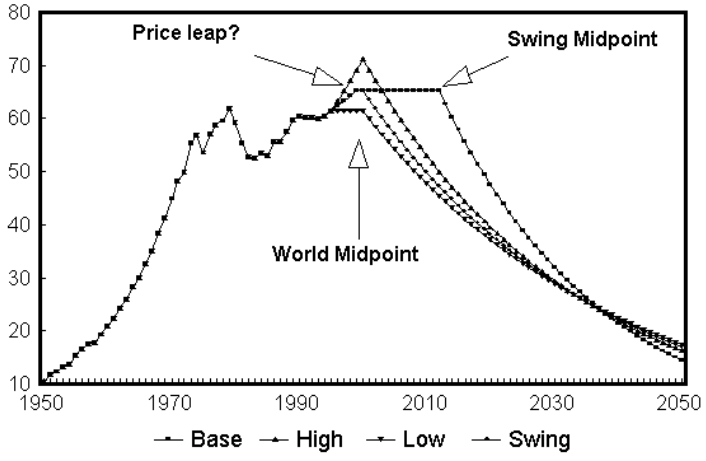
Oil reserves (billion barrels)

Country	*OGJ*	*WO*	*Country*	*OGJ*	*WO*
Saudi Arabia	262	262	Libya	30	30
Canada	180*	5	Nigeria	24	32
Iraq	113	115	USA	23	23
UAE	98	63	China	18	24
Kuwait	97	99	Qatar	15	20
Iran	90	100	Mexico	13	17
Venezuela	78	53	Norway	10	9
Russia	60	59	Algeria	9	13

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

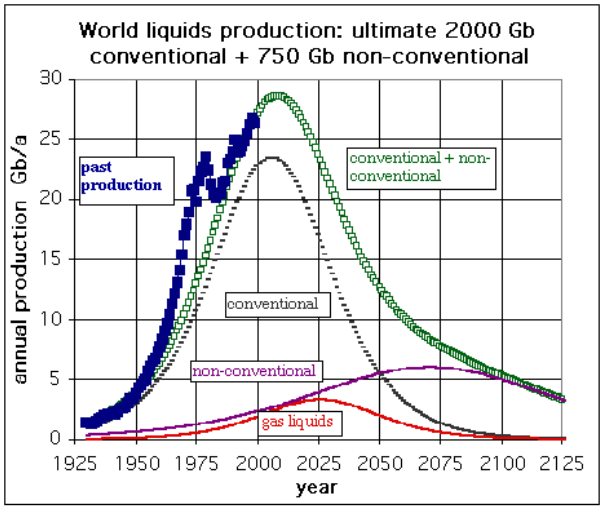
Oil exhaustion (scenario 1)

The Hubbert peak



Graph based on an Ultimate Recovery of conventional oil of 1750 giga barrels, and depicts alternative scenarios of production. Source: Dr. Colin Campbell, 1996 Quoted in http://www.oilcrisis.com/midpoint.htm

Oil exhaustion (scenario 2)



Source: Dr Jean Leherrère
Quoted in http://www.oilcrisis.com/midpoint.htm

Conclusions on energy availability

- No sudden exhaustion of oil reserves
- But, during life of HS line:
  - Increasing shortages of oil
  - Increasing prices of all energy supplies

Climate change

Global warming (averages)

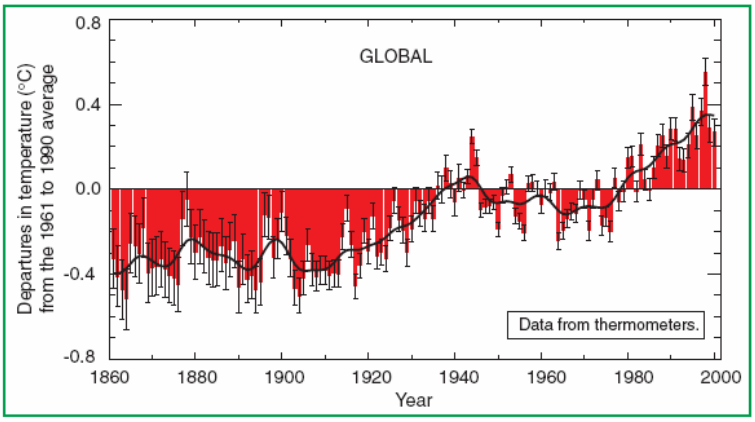
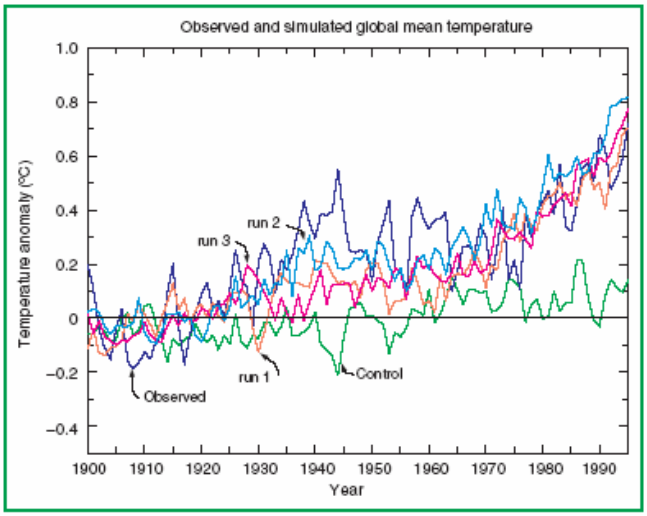


Figure 2: Combined annual land-surface air and sea surface temperature anomalies (°C) 1861 to 2000, relative to 1961 to 1990. Two standard error uncertainties are shown as bars on the annual number. [Based on Figure 2.7c]

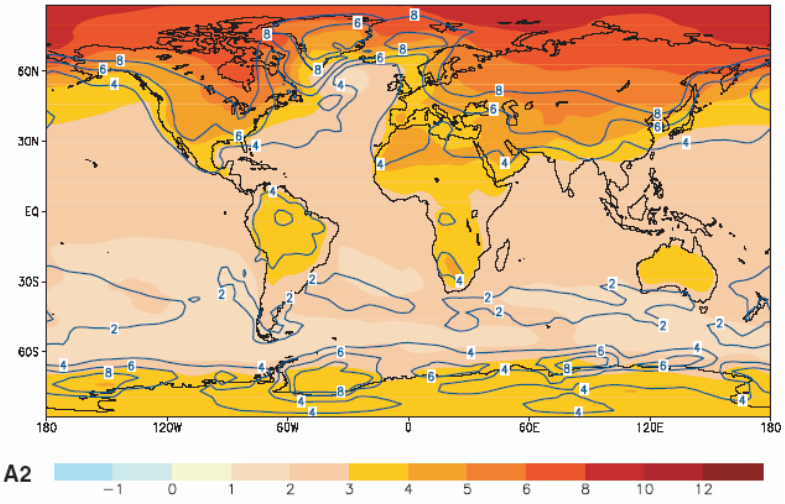
Source: Intergovernmental Panel on Climate Change

Global warming (simulations)



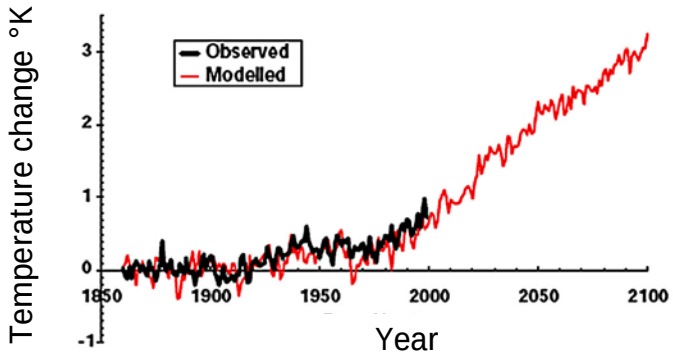
Source: Intergovernmental Panel on Climate Change

Global warming (regional effects)



Source: Intergovernmental Panel on Climate Change

UK Climate change



Source: The Hadley Centre

Global warming (1)

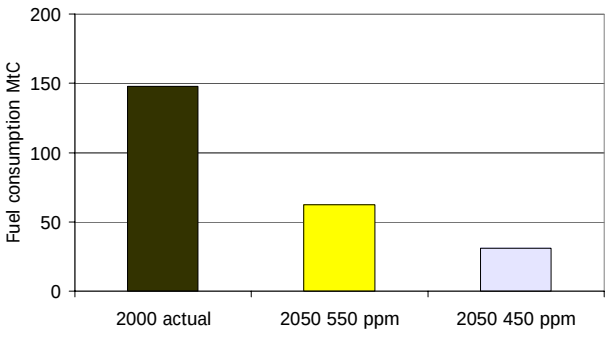
- Little doubt that global warming is happening and extreme weather events are becoming more frequent
- Effects in some geographical areas are likely to be catastrophic
- Balance of scientific opinion is that warming is caused by, or at least exacerbated by, burning fossil fuels

Global warming (2)

- So far, the UK has met Kyoto limits almost by good luck
- No evidence that present UK plans for renewable energy will achieve 2020 targets
- Many consider that present targets for CO_2 are too high and need to be reduced to between 450 and 550 ppm

Reduction in transport fuel use

Assumes principle of "equal pain"



- To achieve 550 ppm CO_2 requires 55% reduction
- To achieve 450 ppm CO_2 requires 79% reduction

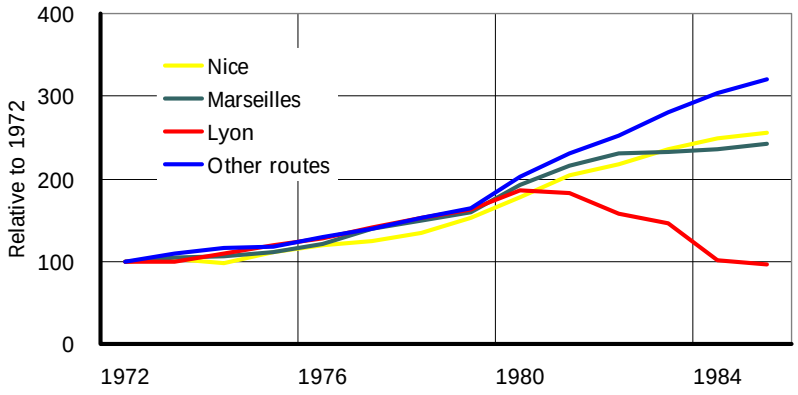
Source: Leeds ITS

Routes to CO_2 reduction

- Increasing efficiency of road and rail vehicles to use 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 ?) to low-consumption modes (rail ?)
- Obtaining energy from non-carbon sources

Modal transfer

Effect of TGV-PSE on domestic air services

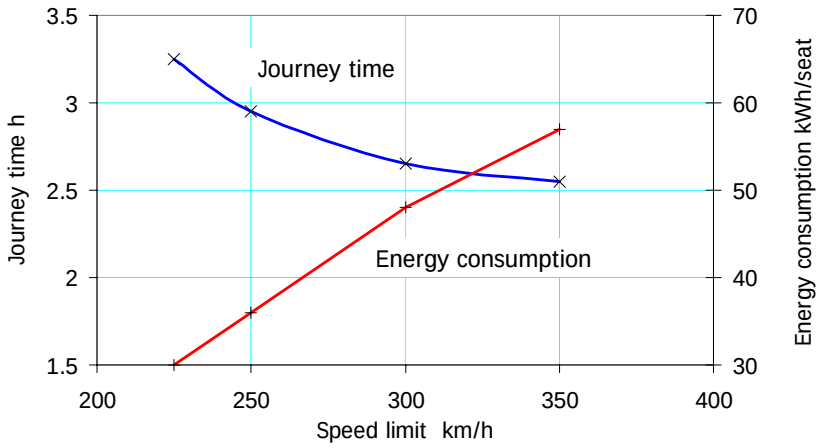


Cut CO_2 in France, due to nuclear generation
Would the same be true in Britain ?

Source: Berlioz & Leboeuf (1986)

Fuel use of inter-city transport

London to Edinburgh by train



Data for NoL Eurostar on hypothetical new line, London – Edinburgh
From: *Passenger Transport after 2000 AD;* Editors: Feilden et al.

London to Edinburgh by train

350 km/h, electricity generated from hydrocarbons

- Energy use per seat * 57 kWh
- Efficiency of train and transmission 0.65
- Generated at power station 88 kWh
- Power station efficiency 0.40
  (1 kWh = 8.3 x 10^{-5} tonnes oil equivalent)
- Primary fuel consumption per seat 22 litres

* Assumes every seat occupied

London to Edinburgh by car

VW Passat 130 TDI

- Distance 600 km
- Consumption * 5.8 litres/100km
- Occupants (in a 5-seat car) 2
- Total consumption/seat 17.4 litres
- Primary fuel 22 litres
  - Assumes 80% refinery/distribution efficiency

* official consumption figure

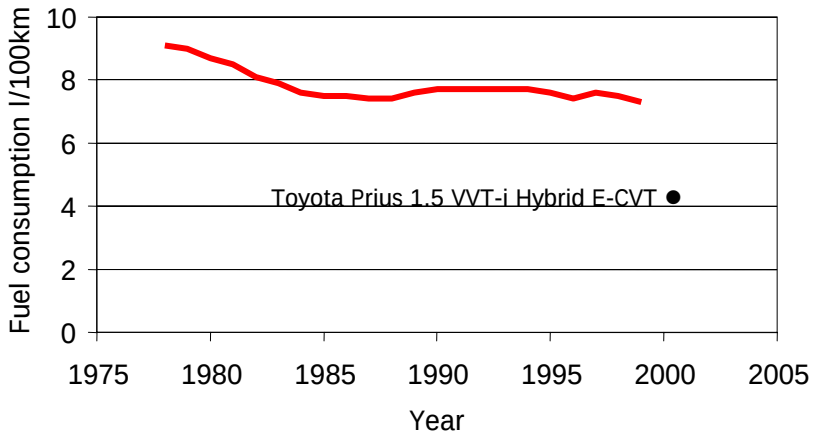
Over-simplistic ?

Car : 1.9 litres 5 seats

Train : 19 litres 50 seats

Car fuel consumption

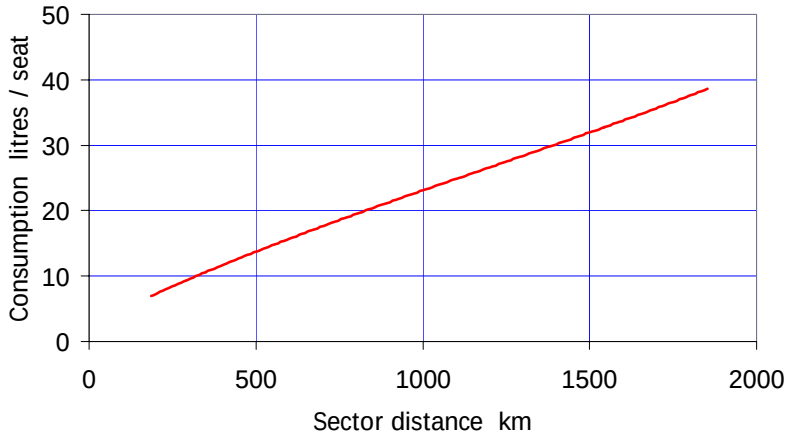
Average of new cars, excluding SUVs



Source: DETR

Airbus consumption vs. sector length

A321-100 single class seating



Source: Airbus

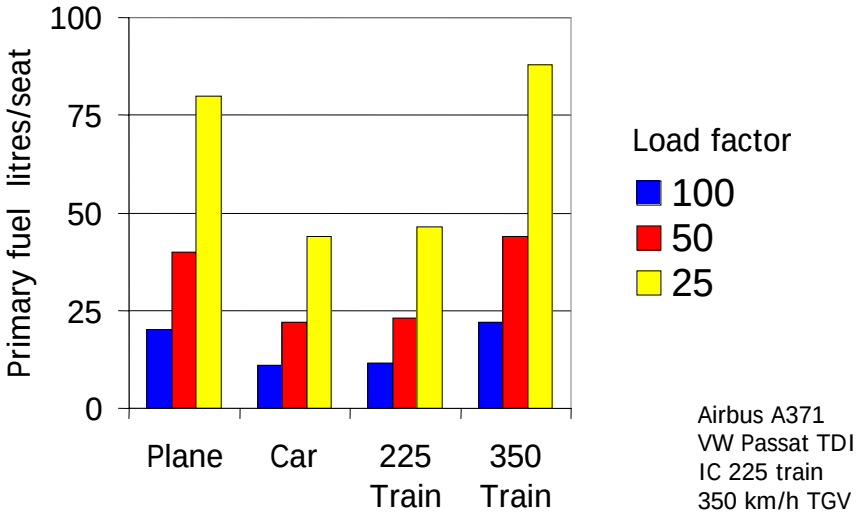
London to Edinburgh by plane

- Distance 600 km
- Consumption * 16 litres/seat
- Primary fuel 20 litres/seat
  - Assumes 80% refinery/distribution efficiency

* assumes 100% load factor

Fuel consumption / passenger

London - Edinburgh



Conclusions

If electricity is generated from fossil fuels:

- Travel by conventional rail contributes as much to global warming as travel by car
- Over a 600 km sector, travel by high speed rail is as environmentally unfriendly as air travel
- Bearing in mind that shorter journey times will increase travel, construction of high speed lines has a detrimental environmental impact

A “green” high-speed line ?

- Modest top speed, 200 – 250 km/h
- Non-carbon energy sources: renewables, nuclear
- High capacity, wide bodied, double deck EMUs
- Lightweight, low drag (articulated, smooth, aerodynamic)
- High passenger utilisation: serves major population centres
- Targets “1 person/car” market, in preference to groups
- Discourages travel growth (e.g. longer commuting distances)
- Provides capacity for parcels, mail and similar services
- Frees-up other lines to allow modal transfer of freight

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