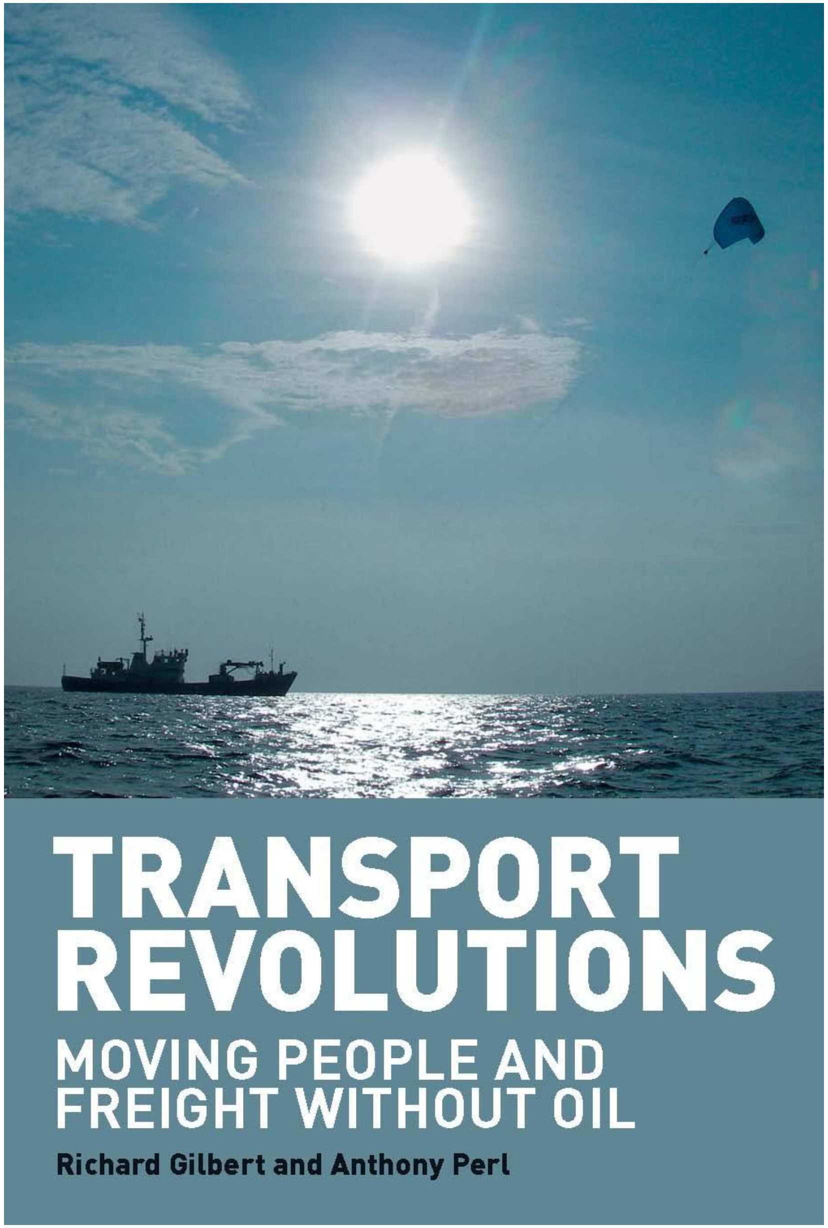

Cover picture: The buoy tender *MS Beaufort* deploying a towing kite on the Baltic Sea

Preparing Transport for Oil Depletion: Focus on China and the U.S.

Presentations in the UK by Richard Gilbert
28 January-6 February, 2008

The presentations are listed
on the next page

For more information about the book
Transport Revolutions: Moving People and Freight without Oil
by Richard Gilbert and Anthony Perl
visit www.transportrevolutions.info

Richard Gilbert's Web site is at
www.richardgilbert.ca

Presentations in the UK by Richard Gilbert, 28 January–6 February, 2008

28 January	Meeting of the All-Party Parliamentary Group on Peak Oil, House of Commons, London
29 January	Seminar held by the Transport Operations Research Group, School of Engineering and Geosciences, Newcastle University
30 January	Seminar held jointly by the Centres for Transport Studies, Imperial College London and University College London
31 January	Seminar held by the Transport Studies Unit, Centre for the Environment, Oxford University
1 February	Seminar held by the Institute for Transport Studies, Leeds University
5 February	Seminar held by the Stockholm Environmental Institute, University of York
6 February	Seminar held by the Centre for European, Regional and Transport Economics, Keynes College, University of Kent

Acknowledgements

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This presentation is part of a lecture tour supported in part by the Post Carbon Institute (PCI), a think, action and education tank offering research, project tools, education and information to implement proactive strategies to adapt to an energy-constrained world. PCI is based in California and has an office in Bristol, UK.

Table of contents of *Transport Revolutions*

Defining a Transport Revolution

- **Definition**: A transport revolution is a *substantial change* in a society's transport *activity*—moving people or moving freight, or both—that occurs in less than about 25 years.

- 'Substantial change' means that an ongoing transport activity increases or decreases dramatically, by say 50%, or use of a new means of transport becomes part of the lives of 10% of the society's population.

- The book analyzes five previous transport revolutions:
  - The introduction of rail service in the UK in the 1830s and 1840s
  - The great pause in motorization in the US, 1942-1945
  - The big switch in transatlantic travel in the 1950s
  - The introduction of high-speed rail in Japan and France, 1960-1985
  - The massive expansion of air freight in the 1980s.

- Some conclusions: Revolutionary change in transport can move quickly in ways its agents fail to predict. It can be especially dramatic when driven by governments set on bolstering national security. Both technological and organizational change can drive transport revolutions.

The Coming Transport Revolutions

- We see revolutions in every transport mode during the next 25 years, because every mode is now fuelled predominantly by a product of crude oil, and oil is likely to become scarce or expensive, or both.

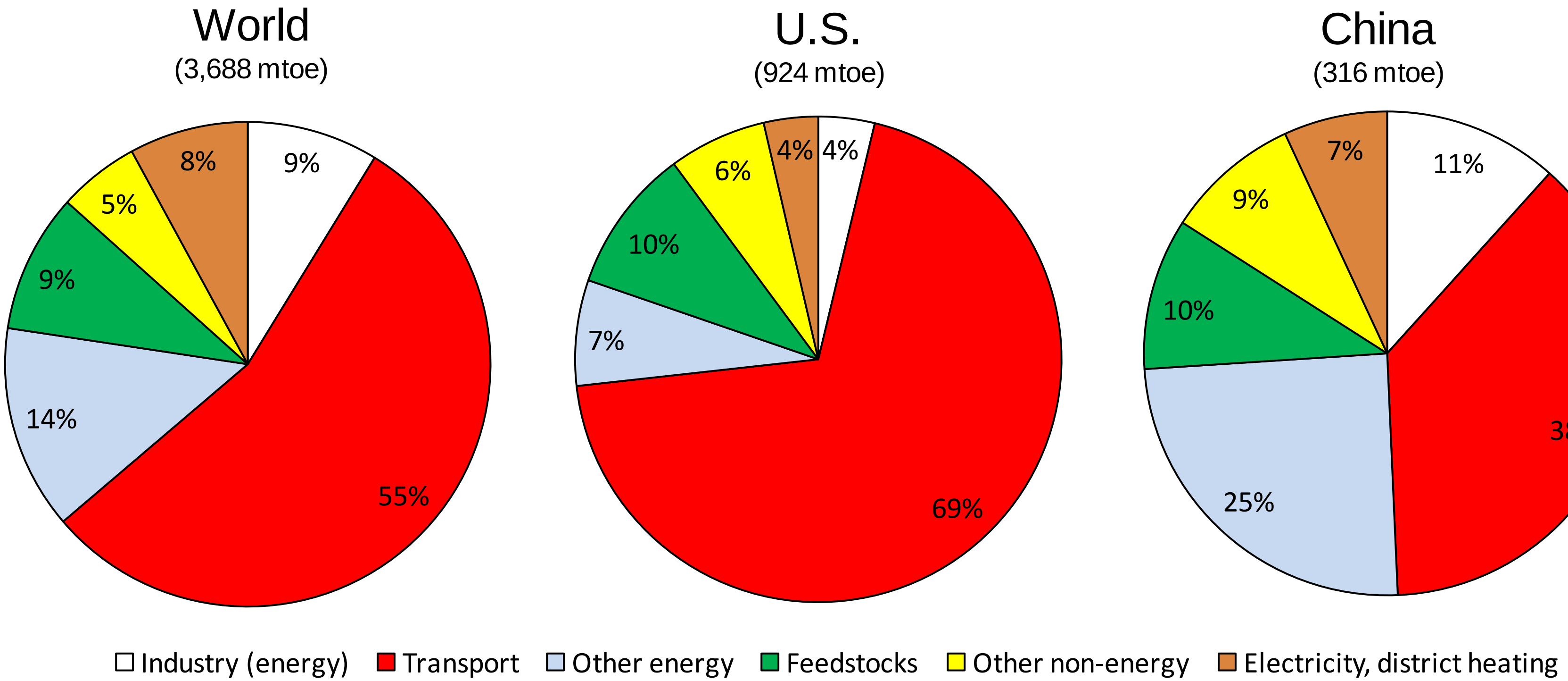
- Transport is especially vulnerable to changes in oil's availability. Overall 95% of transport activity is fuelled by oil products, and transport comprises 55-60% of oil consumption.

- Aviation could be the most vulnerable mode because flying is energy-intensive, it is especially sensitive to fuel-price changes, and there are no promising non-oil alternatives to jet kerosene.

- Rail could be the least vulnerable mode because it is energy-efficient and can be readily fuelled by electricity, which can be produced without oil, even renewably.

Oil's end uses in 2004: World, U.S., and China

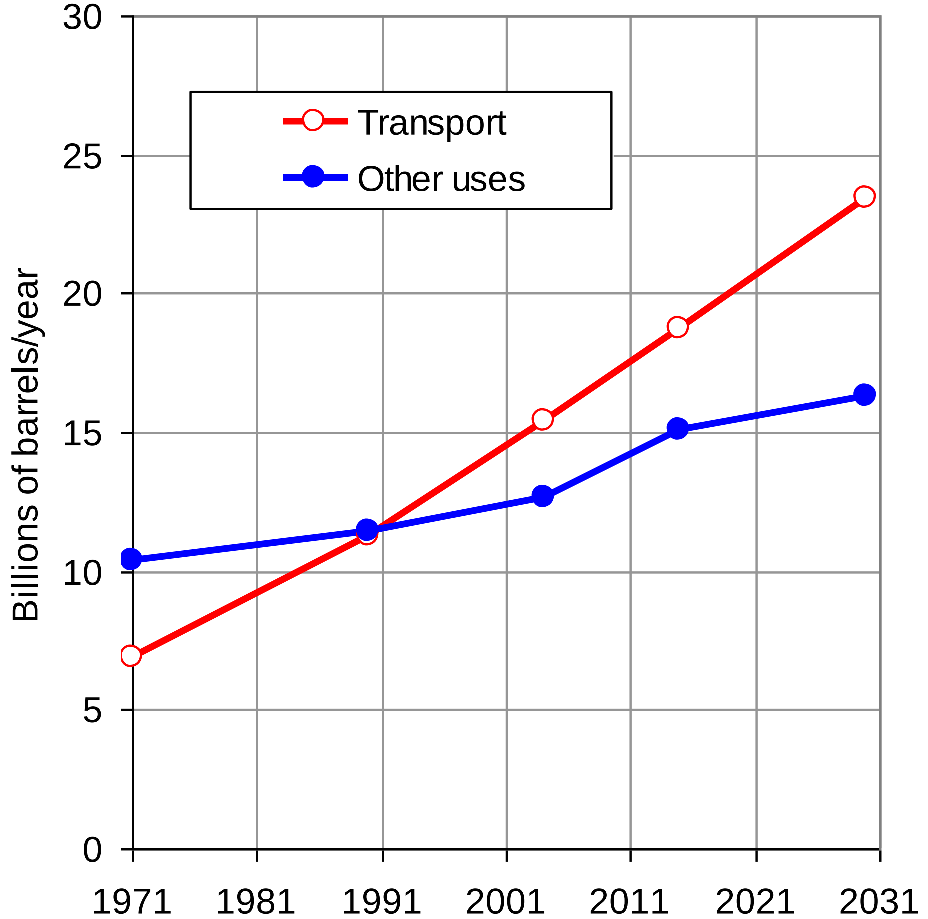
Worldwide, just over half of oil's end use is for transport, more in richer countries, especially the US. Within transport's share, roughly 2% is used for moving oil around. Before end uses, about 7% of what is extracted is used for extraction and refining.



mtoe = millions of tonnes of oil equivalent

Sources: International Energy Agency (2006a, 2006b)

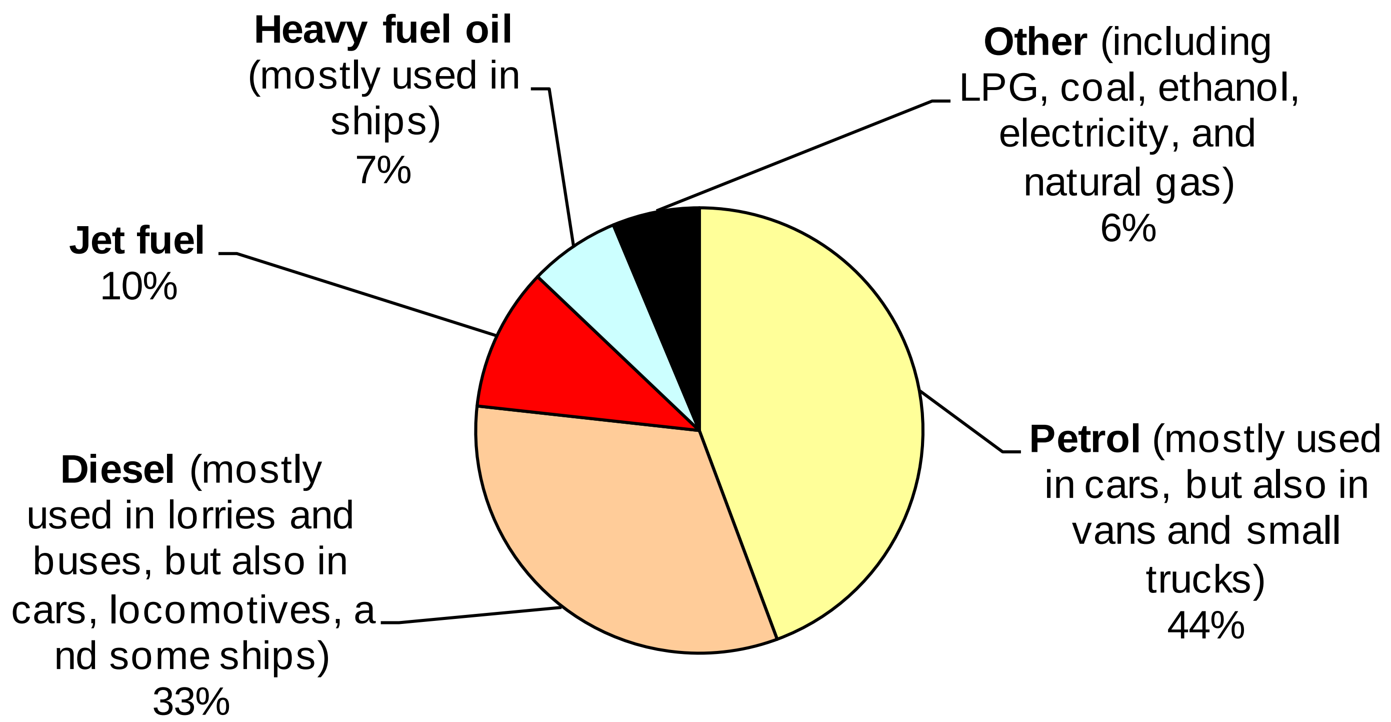
Worldwide, oil use for transport grows more quickly than other oil uses



Sources: International Energy Agency (2004, 2004, 2006)

Transport fuels, world, 2003

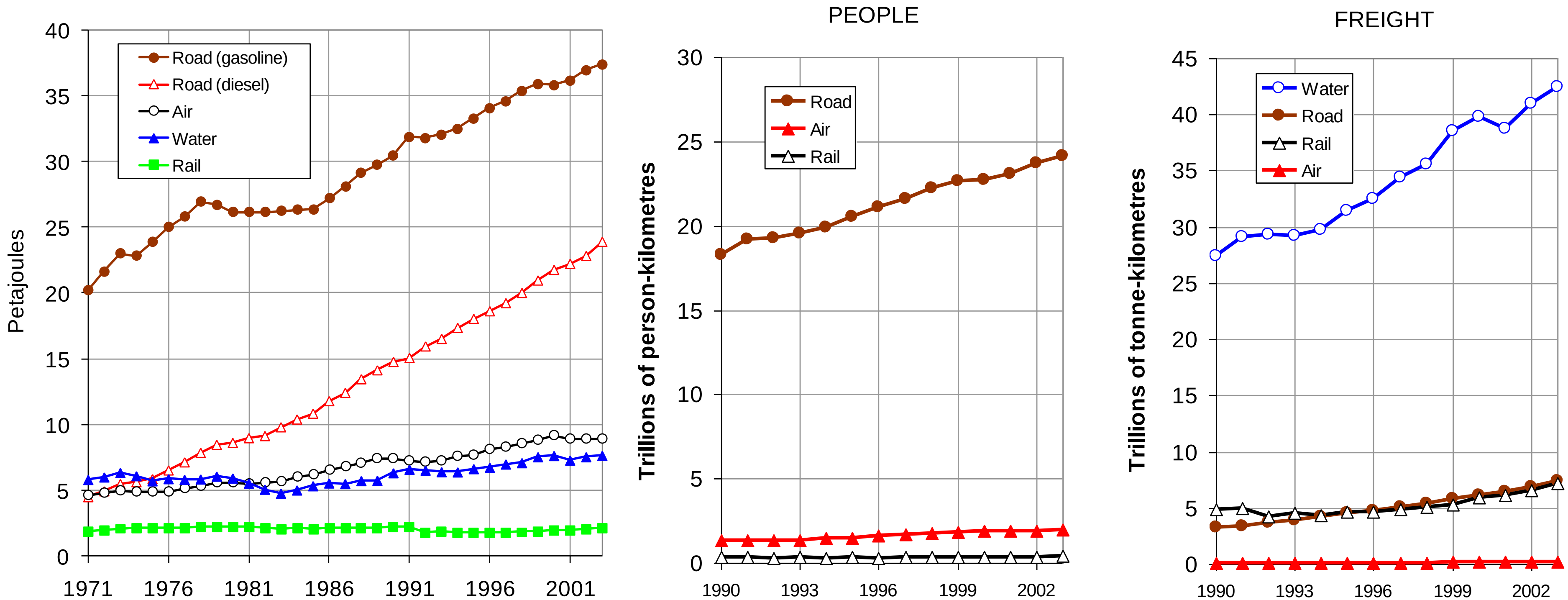
About 95% of transport is fuelled by oil, divided almost equally between gasoline and less volatile fuels, chiefly diesel, jet fuel (kerosene), heavy fuel oil (bunker fuel).



Source: Organization for Economic Cooperation and Development (2006)

World trends in transport energy use and activity by mode

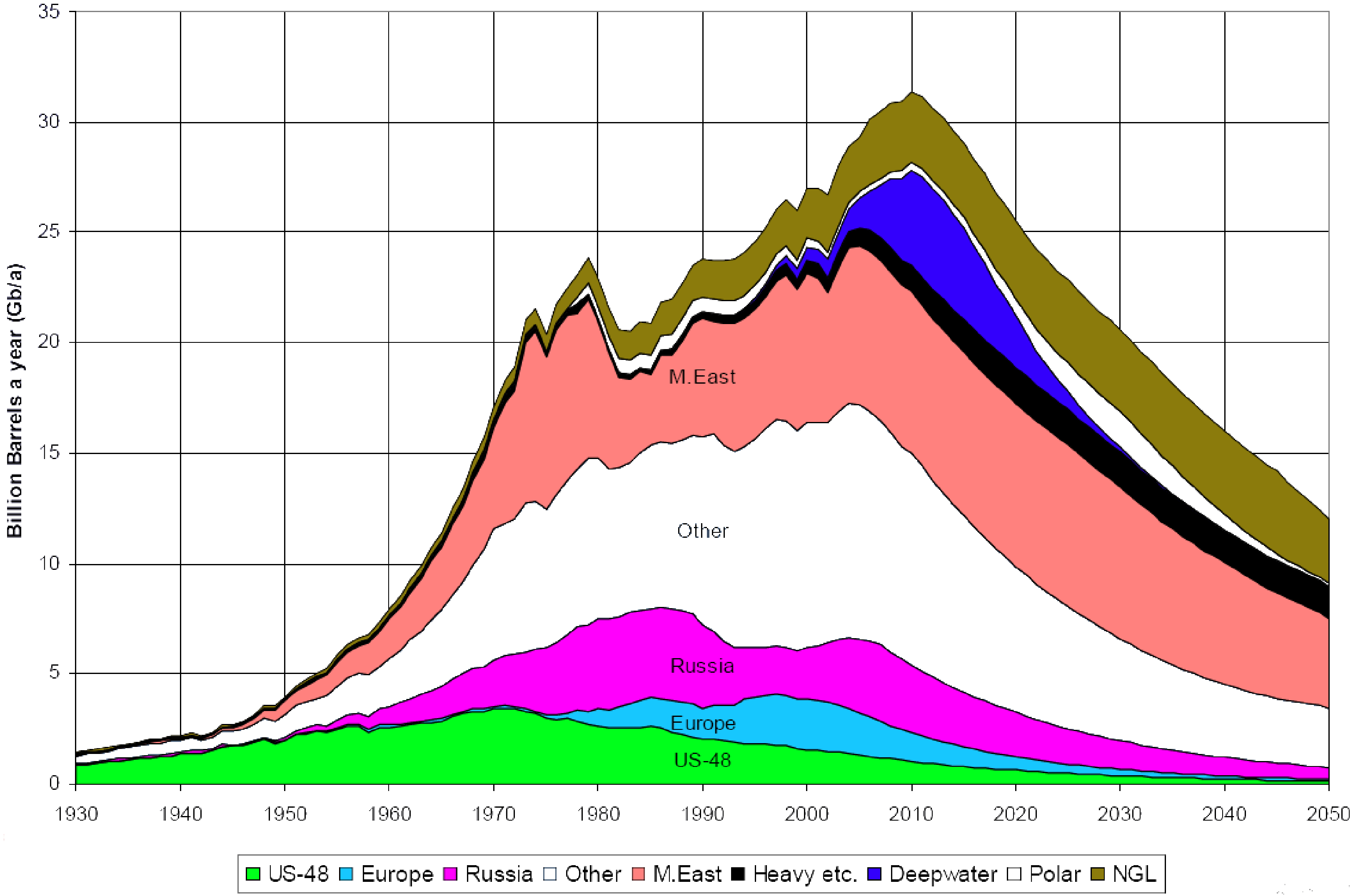
The chart on the left shows worldwide transport *energy use* by mode: >75% goes to road uses. The two charts on the right show transport *activity* by mode, separately for moving people and moving freight. Note the dominance of marine freight.



Source: Organization for Economic Cooperation and Development (2006)

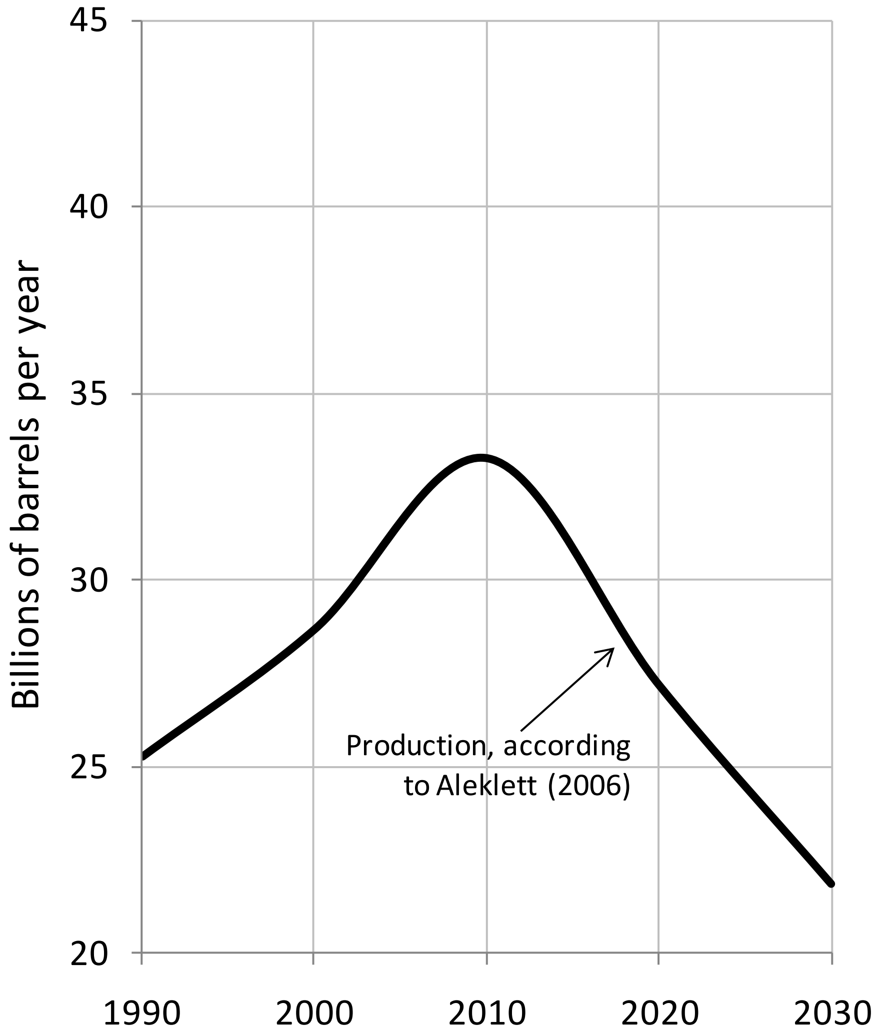
Actual and projected production of petroleum liquids, world, 1930-2050

Conventional oil production is shown by region; other oil production is shown by type



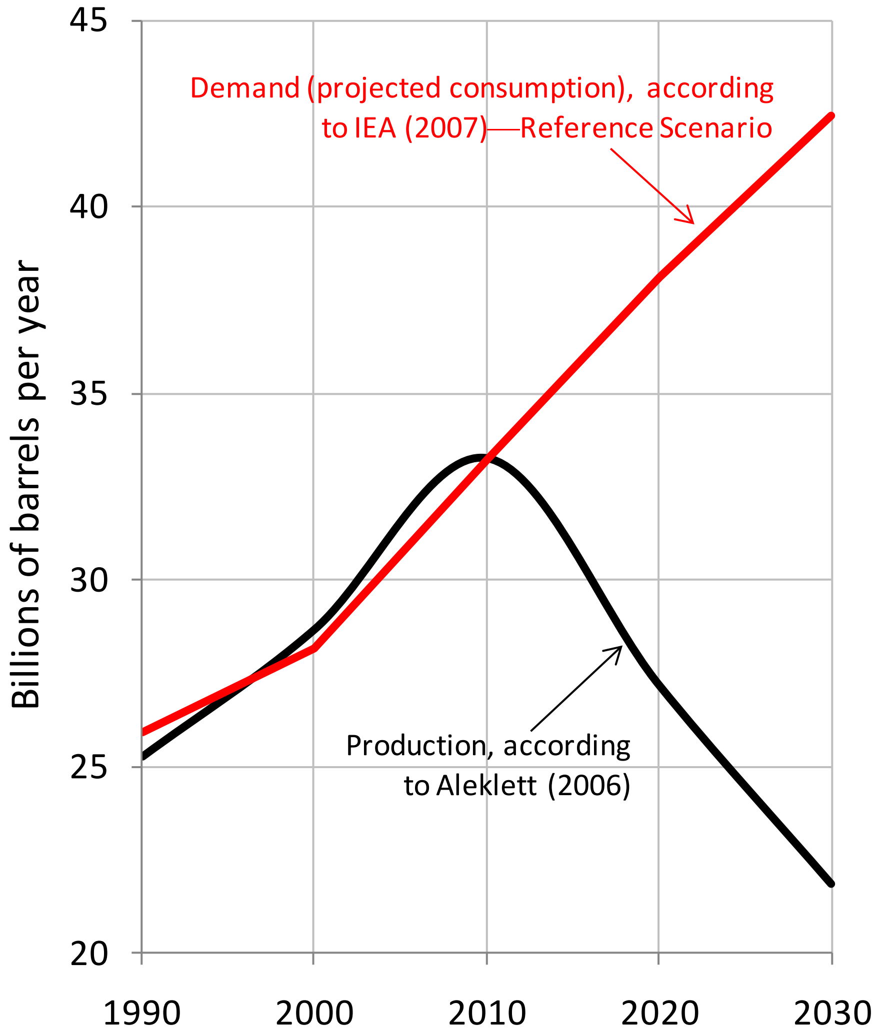
Source: Aleklett (2006)

Schematic of part of previous chart: Total world production of petroleum liquids, 1990-2030



bb/y	mb/d
20	55
25	68
30	82
35	96
40	110
45	123

Adding in IEA's latest Reference Scenario for future demand ('business-as-usual')



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20	55
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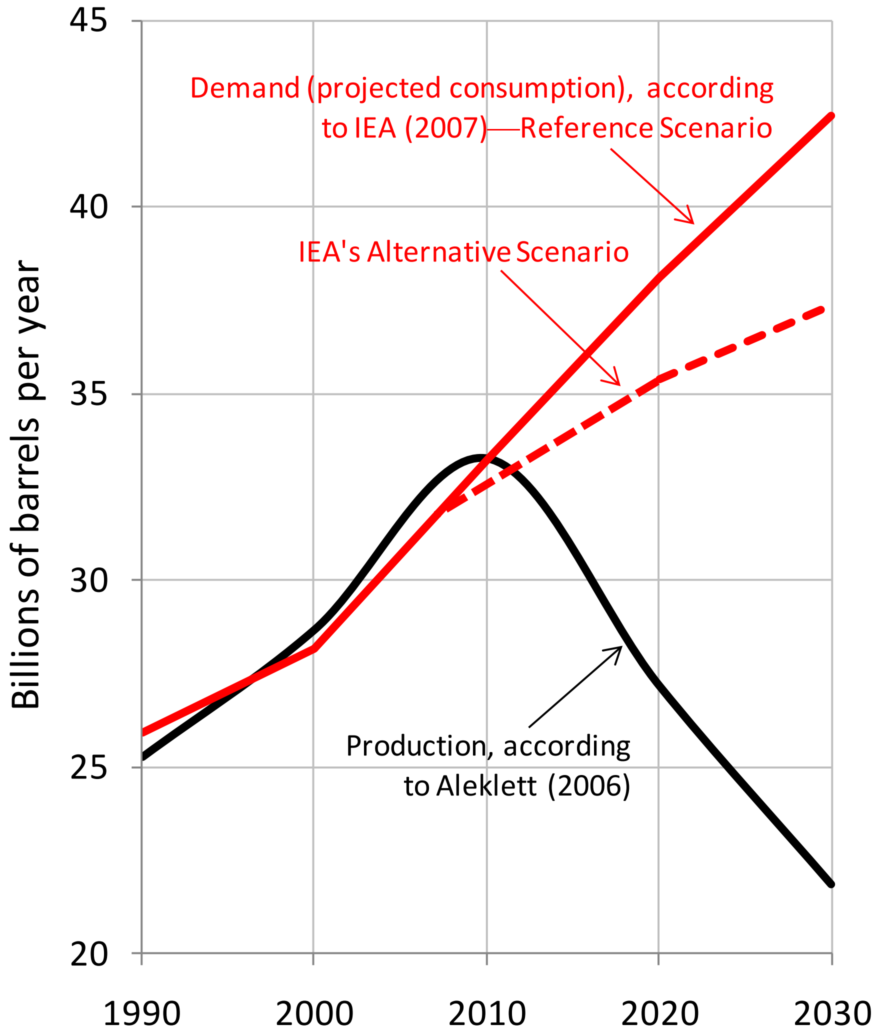
Adding in IEA's latest Alternative Policy Scenario for future demand

(assumes implementation of "all the policies that governments around the world are considering today")



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20	55
25	68
30	82
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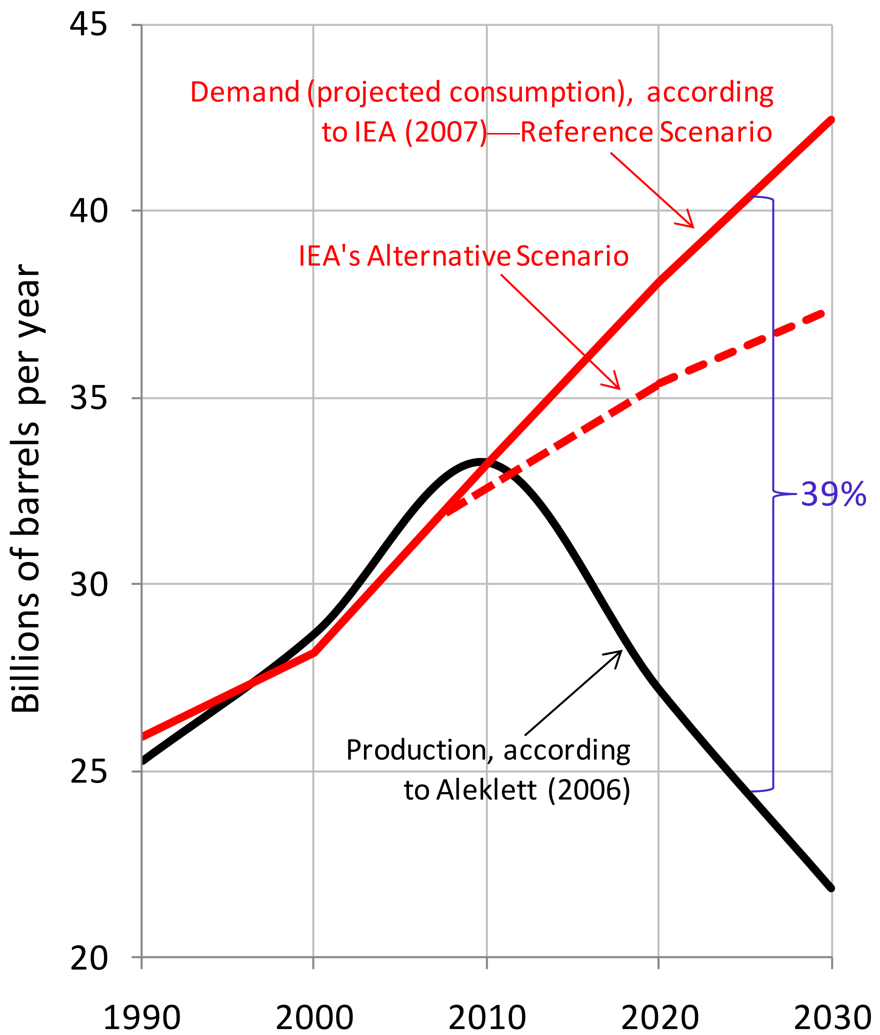
For the Reference Scenario, there would be a supply shortfall of about 39% in 2025

(compared with the Uppsala supply projection; IEA assumes supply can be made available to meet demand)



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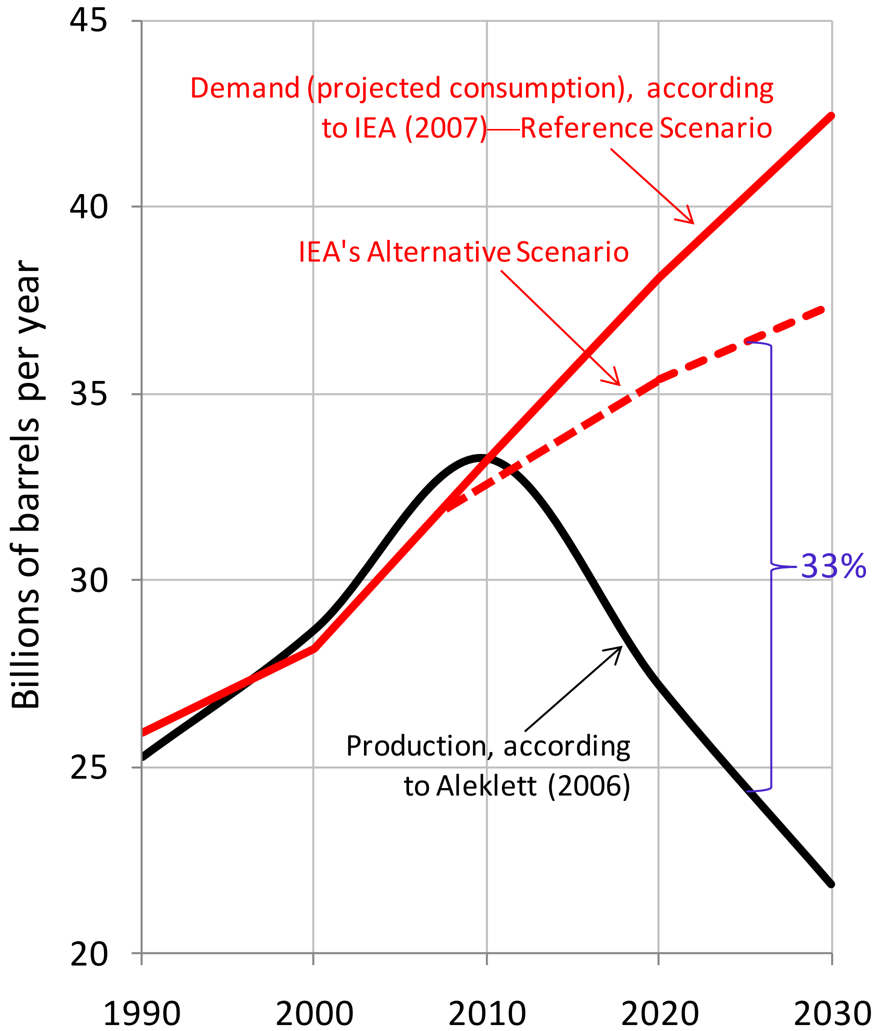
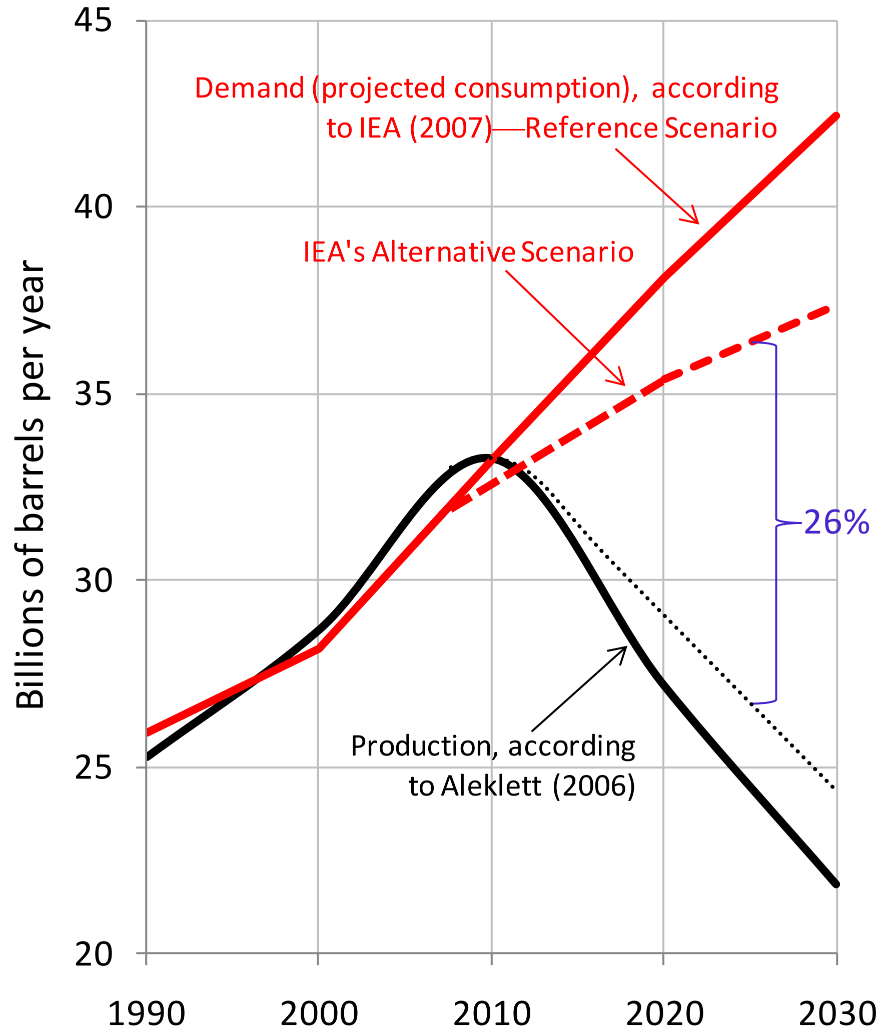


bb/y	mb/d
20	55
25	68
30	82
35	96
40	110
45	123

High prices could raise production, despite the cost of overcoming geological constraints

(the thin dotted line suggests where supply and demand could be balanced by higher prices)



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35	96
40	110
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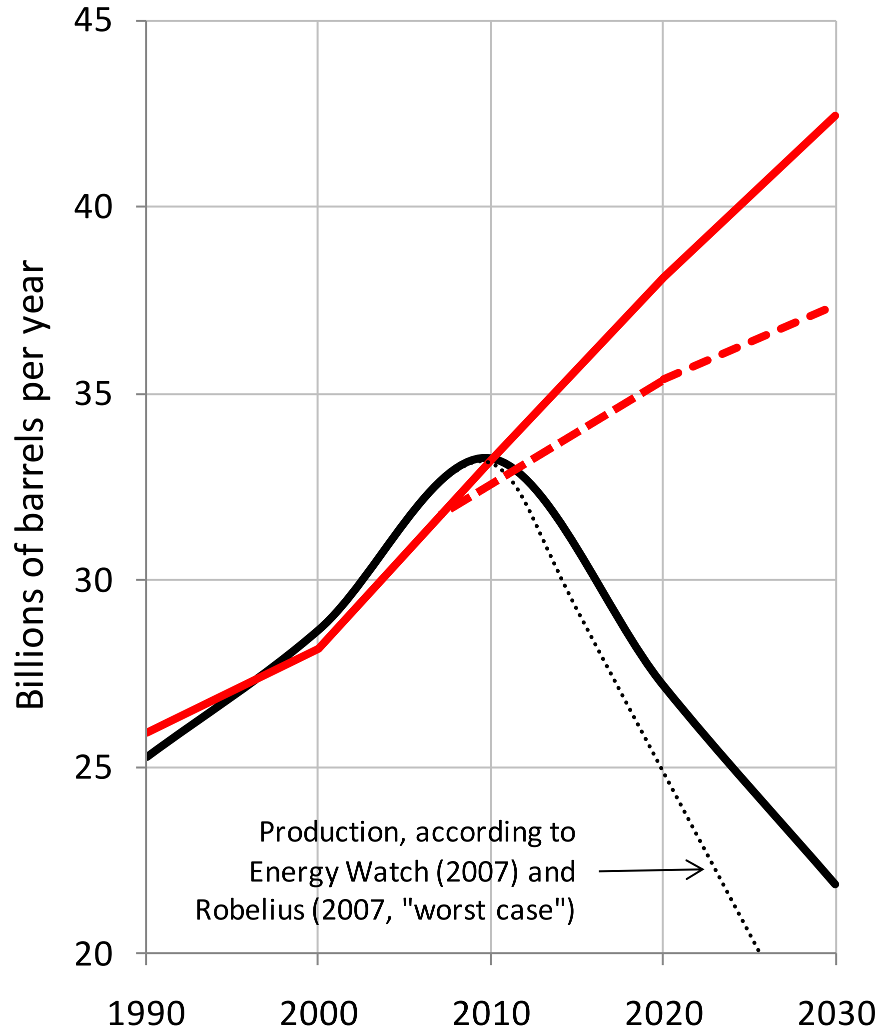
Other projections suggest an even steeper decline in production of petroleum liquids



Impact of economic recession on oil consumption?

bb/y	mb/d
20	55
25	68
30	82
35	96
40	110
45	123

Whether oil production will decline is controversial

- IEA appears to assume its demand projections can be met by sufficient supply, as do BP, Exxon-Mobil, and Cambridge Energy Research Associates (US).

- IEA has also said, "Despite four years of high oil prices, this report* sees increasing market tightness beyond 2010, with OPEC spare capacity declining to minimal levels by 2012".

- The CEOs of Total, ConocoPhillips, Shell, and Libya's national oil company have suggested that world supply will peak well before it reaches levels required by IEA's demand projections.

- James R. Schlesinger, the first US Secretary for Energy, and Secretary for Defense and head of the CIA, said in Ireland in September, "Conceptually the battle is over, the peakists have won. … we are all peakists now".

* IEA, *Medium Term Oil Market Report*, July 2007

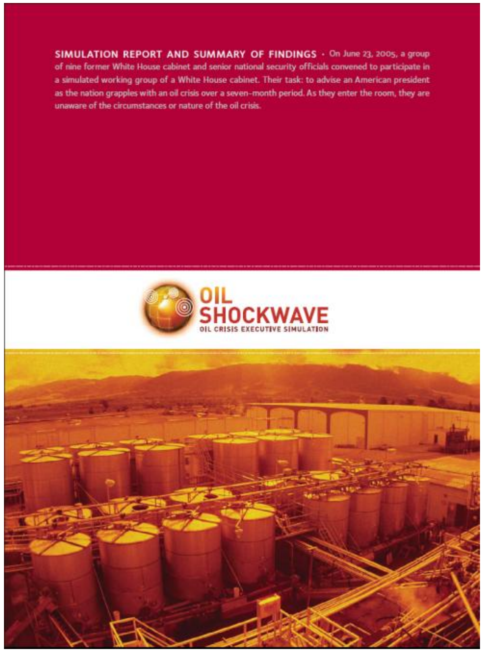
Small shortfalls could mean big price increases (two analyses)

①

Based on a 2002 analysis by the Brookings Institution

	Shortfall in crude oil supply			
	0%	5%	10%	15%
Resulting increase in crude oil price	0%	30%	200%	550%
Crude oil price per barrel (US$)	$50	$65	$150	$320

②



The U.S. National Commission on Energy Policy concluded in June 2005 that a "4 percent global shortfall in daily supply results in a 177 percent increase in the price of oil" (from $58 to $161 per barrel).

Our working conclusion

Prudence requires preparation for a world shortfall in supply in 2025 of about 35% in relation to IEA's Reference Scenario. This would be a fall by about 17% from 2007 production of petroleum liquids.

- The fall in production could be anticipated by ratchetting down consumption in advance of the fall in production. This would allow a 'soft landing' into oil depletion.
- The fall in consumption could be forced by high prices resulting from a large shortfall between production and potential consumption. This would be a 'hard landing' into oil deletion, perhaps resulting in severe economic, social, and geopolitical disruption.
- Planning for a 'soft landing' could be worthwhile even if oil depletion were not to happen, to reduce pollution, moderate climate change, and avoid the high cost of oil imports.

Whether potential demand will continue to rise is questionable

Potential demand for oil (likely future consumption at specified prices) could be moderated by several factors, including:

- much improved efficiency of transport activity that is not offset by increased activity
- reduced transport activity arising from, say, economic recession.

"Prediction is very hard", said Neils Bohr and Yogi Berra, "especially about the future".

Whether prices will rise steeply is questionable

- The relationships among supply, demand, and the price of oil are not well understood. For example, some steep price rises since 2002 have not had the expected impacts.
- In the US between 2002 and 2007, retail petrol prices doubled (+78% in real terms), largely because of a threefold increase in crude oil prices.
- Petrol consumption also increased, but at about the same rate—9% overall and 4% per capita—as in the previous five years, across which real retail prices hardly changed.
- Just as price increases have not had the expected effect of pushing down consumption, so might a shortfall between supply and demand not have the expected effect of pushing up prices.

In spite of the uncertainties, we stay with our working conclusion

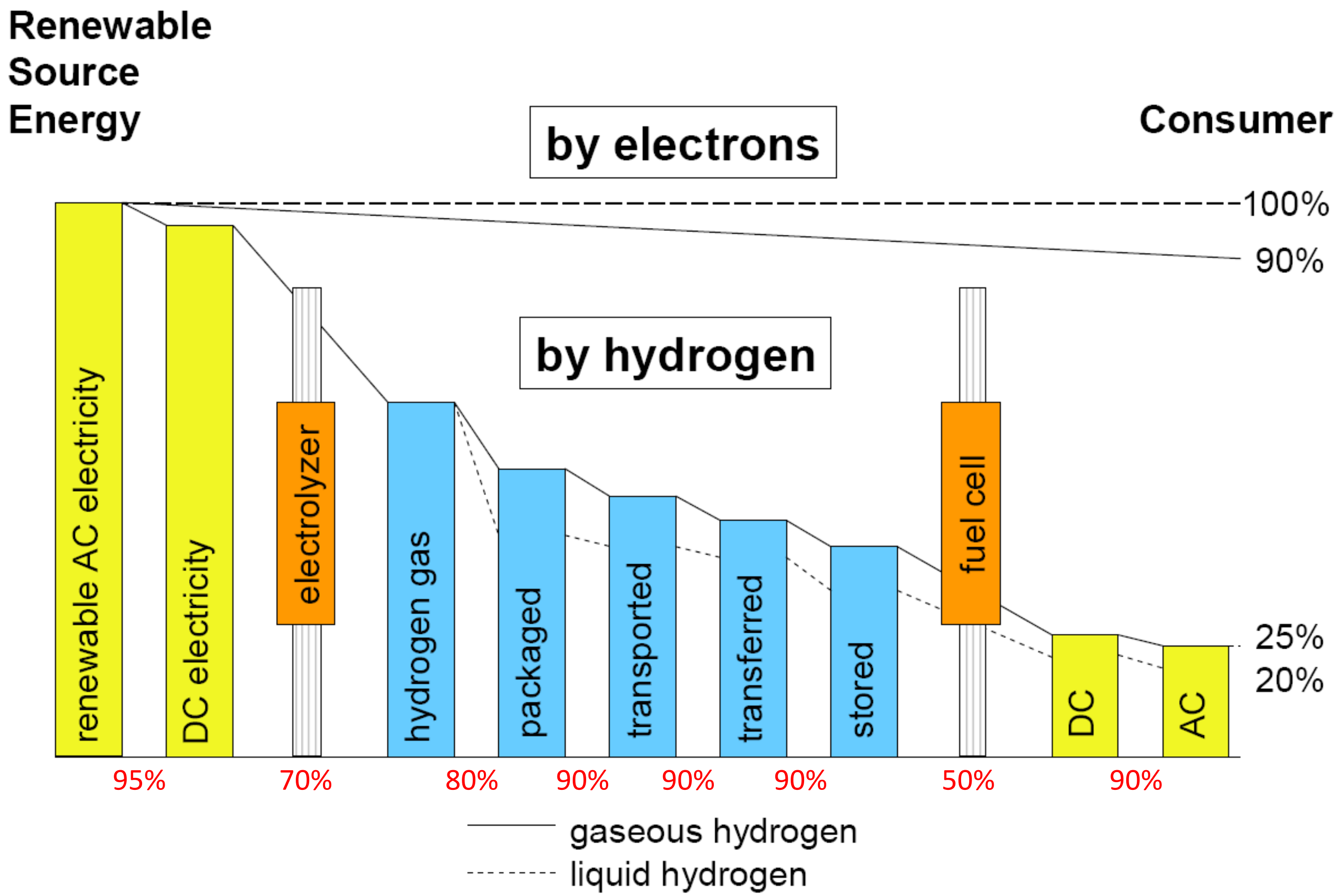
Prudence requires preparation for a world shortfall in supply in 2025 of about 35% in relation to IEA's Reference Scenario. This would be a fall by about 17% from 2007 production of petroleum liquids.

Later in this presentation, this conclusion is translated into required actions for richer and poorer countries.

Alternatives to oil as a transport fuel

- Biofuels: issues of soil depletion and competition with food production limit biofuels' prospects as major replacers of oil.
- Natural gas: has a later world production peak than oil, although now peaking in North America; it is difficult to move between continents; it can be used to make liquid transport fuels (Fischer-Tropsch process).
- Coal can be used to make liquid fuels using the Fischer-Tropsch process.
- Hydrogen: now made from natural gas; could be made from electricity; but inefficiently (see next slide), so use electricity directly.
- Electricity: the perfect transport fuel except for the challenge of on-board storage; thus emphasize the use of grid-connected vehicles.
- Increased electricity use brings the prospect of more use of coal and uranium; but both may be approaching peak production; therefore use renewable sources of electricity, including solar thermal.

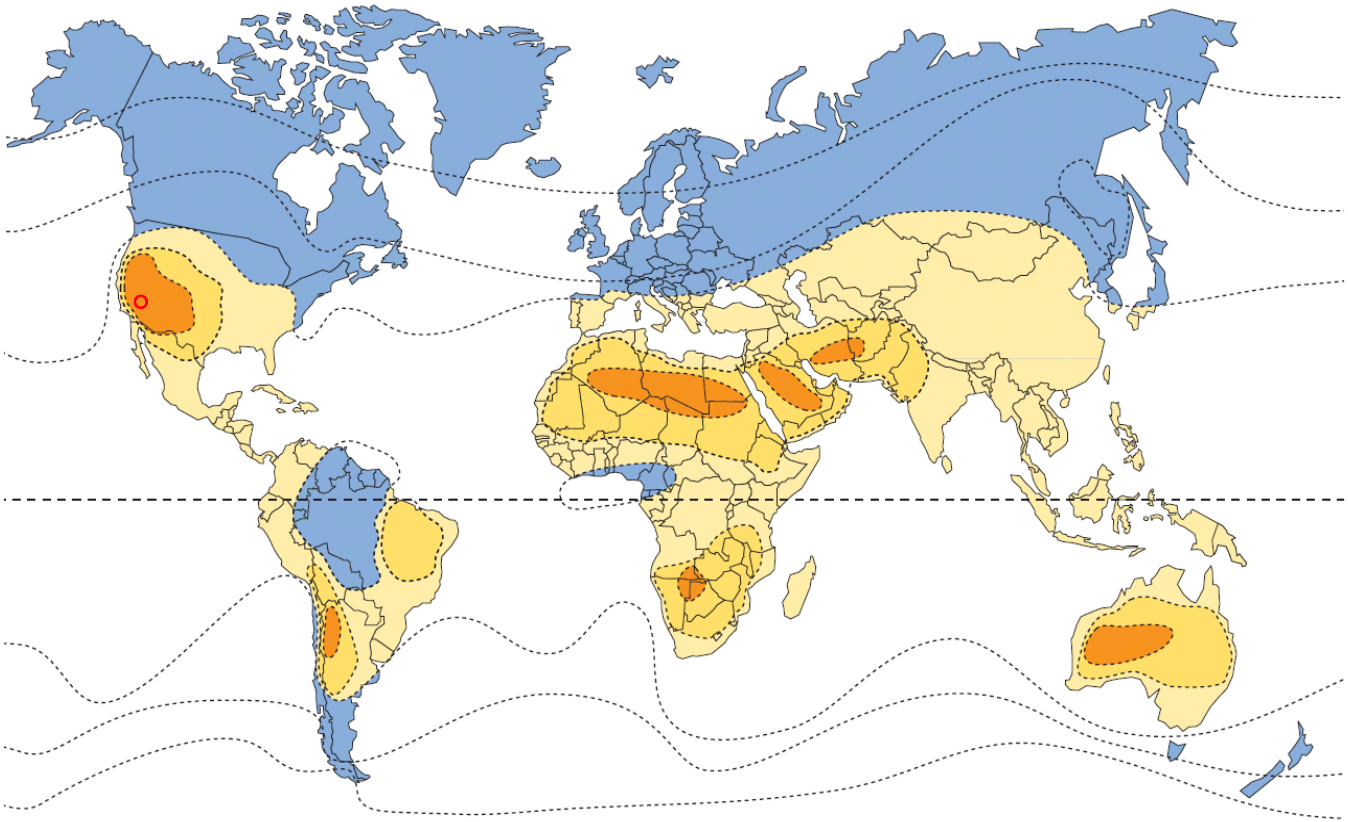
Why the hydrogen fuel cell future won't work (but grid-connected vehicles will)



Source: Bossel (2005)

California and North Africa are ideal solar thermal power plant sites

The area in the red circle in California could supply sufficient energy to replace the entire US grid.
The population centres and industry in the North could be reached by high-voltage DC lines.



Suitability for solar thermal power plants:

Excellent Good Suitable Unsuitable

Source: Rutledge/Schott (2006)

Other non-fossil sources of electricity

- Marine energy (tidal barrages, marine currents, wave energy – could supply 25% of current UK generation?)
- Geothermal (high temperature) and geoexchange (even lower temperature)
- Wind (address intermittency with vanadium flow batteries?)
- Biomass (fuelling thermal electricity generation with it is more efficient than producing liquid fuels, but soil depletion?)
- Nuclear (James Lovelock: “I am a Green and I entreat my friends in the movement to drop their wrongheaded objection to nuclear energy”)

However, conservation is the most effective and efficient investment (UK’s per-capita rate of electricity use is relatively low but increasing rapidly)

“I believe strongly we have to get off oil. The electrification of the automobile is inevitable.” Bob Lutz, VP General Motors, *Newsweek*, 31 December 2007.

Transport Revolutions

In anticipation of or in response to Oil Depletion, there will be at least three transport revolutions:

(i) on land, increasing use of electric motors in place of internal combustion engines

(ii) increasing use of rail and *low-speed* marine transport in place of road and air

(iii) increasing use of collectively managed transport in place of personally managed transport.

Transport Revolutions: moving *between* cities

1. Local, inter-city, and international movement of people and freight will all change profoundly.

2. Longer-distance movement of people will be increasingly by train, some high-speed, mostly electric.

3. Aviation will be confined increasingly to large aircraft flying infrequently among many fewer airports.

4. Bus/coach travel will be available where trains do not go, increasingly electrified.

5. Some inter-city car travel will continue, increasingly electrified.

Transport Revolutions: moving *within* cities

1. There will be more walking, cycling, and use of public transport, even Personal Rapid Transport (PRT – Heathrow, Dubai, Abu Dhabi).

2. Other public transport will become electric and frequent.

3. Destinations will be nearer and more often walked or cycled.

4. Cars will still be used, increasingly electric cars.

5. Local freight movement will become more efficient through load consolidation at distribution centres; delivery vehicles will be electric.

Process for accommodating oil depletion 1

The framework is our conclusion above: "Prudence requires preparation for a world shortfall in supply in 2025 of about 35% in relation to IEA's Reference Scenario. This would be a fall by about 17% from current production of petroleum liquids."

The first step is to allocate this shortfall between richer and poorer countries. We chose actual 1990 consumption as the basis for allocation, i.e., richer countries bear about three quarters of the shortfall, as in the following table.

The result is that richer countries cut oil use by 40%; poorer countries raise it by 23%.

	Actual 1990	Likely 2007	BAU project-tion 2025	Target 2025	Percentage differences of 2025 target from		
					Actual 1990	Likely 2007	BAU 2025
	Billions of barrels (bb)						
Richer countries	18.8	20.3	22.4	12.2	-35%	-40%	-46%
Poorer countries	5.8	11.5	18.0	14.1	+145%	+23%	-22%
World	24.5	31.8	40.4	26.3	+7%	-17%	-35%

Process for accommodating oil depletion 2

1. For each of richer and poorer countries, set the overall reduction in oil use—according to supply projections—and set corresponding, acceptable changes in motorized activity.

2. For each mode, for richer and poorer countries, estimate current transport activity and unit energy use.

3. Anticipate available modes in 2025 and their energy use.

4. Develop plausible balances of 2025 modes that meet the parameters for energy use and transport activity.

5. Engage in continuous improvement of energy use estimates and proposals for transport activity.

Initial result for moving people

Movement of people (billions of person-kilometres, except per capita)

	US			China			UK
Mode	**2007**	**2025**	**Change**	**2007**	**2025**	**Change**	**2007**
Personal vehicle (ICE)	7,700	5,000	0.6	500	1,250	2.5	700
Personal vehicle (electric)		1,000		200	1,500	7.5	
Future transport (PRT, etc.)		200			500		
Local public transport (ICE)	50	100	2.0	300			25
Local public transport (electric)	40	400	10.0	30	1,000	33.3	10
Bus (inter-city, ICE)	200	500		500	500	1.0	25
Bus (inter-city, electric)		500			500		
Rail (inter-city, ICE)	6	100	16.7	300	100	0.3	20
Rail (inter-city, electric)	3	400	133.3	300	900	3.0	30
Aircraft (domestic)	950	600	0.6	150	150	1.0	10
Aircraft (international)	330	400	1.2	50	100	2.0	300
Airship (domestic and international)		100			100		
Marine (domestic and international)		100		5	100	20.0	
Totals	9,300	9,400	1.0	2,350	7,250	3.1	1,120
Per capita	30,500	26,500	0.9	1,750	5,000	2.9	19,000
Total electrically powered	45	2,500	55.6	730	4,400	6.0	30
Mean MJ/pkm for ICI-based movement	2.5	1.9	0.8	1.5	1.1	0.7	1.9

Sources: Chiefly U.S. Bureau of Transportation Statistics (2007); National Bureau of Statistics of China (2007); UK Department for Transport (2007)

Initial result for moving freight

Movement of freight (billions of tonne-kilometres, except per capita)

Mode	US 2007	US 2025	US Change	China 2007	China 2025	China Change	UK 2007
Lorry (ICE)	2,050	1,500	0.7	900	1,600	1.8	180
Lorry (battery)		500			1,000		
Lorry (trolley)		500			500		
Rail (ICE)	2,650	900	0.3	1,050	1,500	1.4	10
Rail (electric)		2,700		1,050	3,000	2.9	15
Pipeline	1,250	800	0.6	100	200	2.0	10
Air (domestic)	15	10	0.7	5	5	1.0	
Air (international)	25	25	1.0	5	15	3.0	5
Airship (dom. and int.)		50			100		
Marine (domestic)	700	1,100	1.6	4,750	5,500	1.2	60
Marine (international)	4,200	3,000	0.7	3,750	5,000	1.3	500
Totals	10,900	11,100	1.0	11,600	18,400	1.6	780
Per capita	35,600	31,200	0.9	8,700	12,700	1.5	13,200
Total electrically powered		3,700		1,050	4,500	4.3	15
Mean MJ/tkm for ICI-based movement	0.8	0.6	0.9	0.5	0.5	0.9	0.6

Sources: Chiefly US Bureau of Transportation Statistics (2007); National Bureau of Statistics of China (2007); UK Department for Transport (2007)

Launching Transport Revolutions in the US

Transport Revolutions begins discussion of *how* to achieve effective transport redesign, full exposition of which would require another book. We set out initial steps:

1. Create a Transport Redevelopment Agency as a forum for consultation, a repository of management and technical expertise, and a banker.

2. Terminate highway and airport expansion programmes; reallocate funds to transport redesign (converting some airports to 'travelports').

3. Raise taxes on oil-based transport fuels; use proceeds for transport redesign.

4. Develop rail, especially passenger rail: electrification, double-tracking, some high speed. Use the electrified, mixed-use Boston-Washington rail corridor as a model.

"America is addicted to oil, which is often imported from unstable parts of the world." US President G W Bush, January 2006.

Launching Transport Revolutions in China 1

Transport Revolutions says less about how to achieve transport redesign in China. There, the scale of change is breathtaking and underestimated:

- China is the world's major consumer of grain, meat, coal, and steel, and second in oil use and (soon) imports. China is more dependent on Middle East oil than the US (and is transforming her military to be able to project her power beyond her national borders).
- Ongoing migration from rural to urban areas is the largest movement of people in history, to involve more than 500 million people between 1985 and 2025, driving growth in prosperity.
- The appetite for material prosperity is extraordinary: seven of the world's 20 largest shopping centres are in China, including the first and second.
- Yet, this appetite is moderated—China consumes only half of what she produces—by subsidy of US affluence (purchase of US Treasury Notes).

"To ask whether China wants urbanization is like asking whether a person wants to eat." Tang Jun, Chinese Academy of Social Sciences, June 2007.

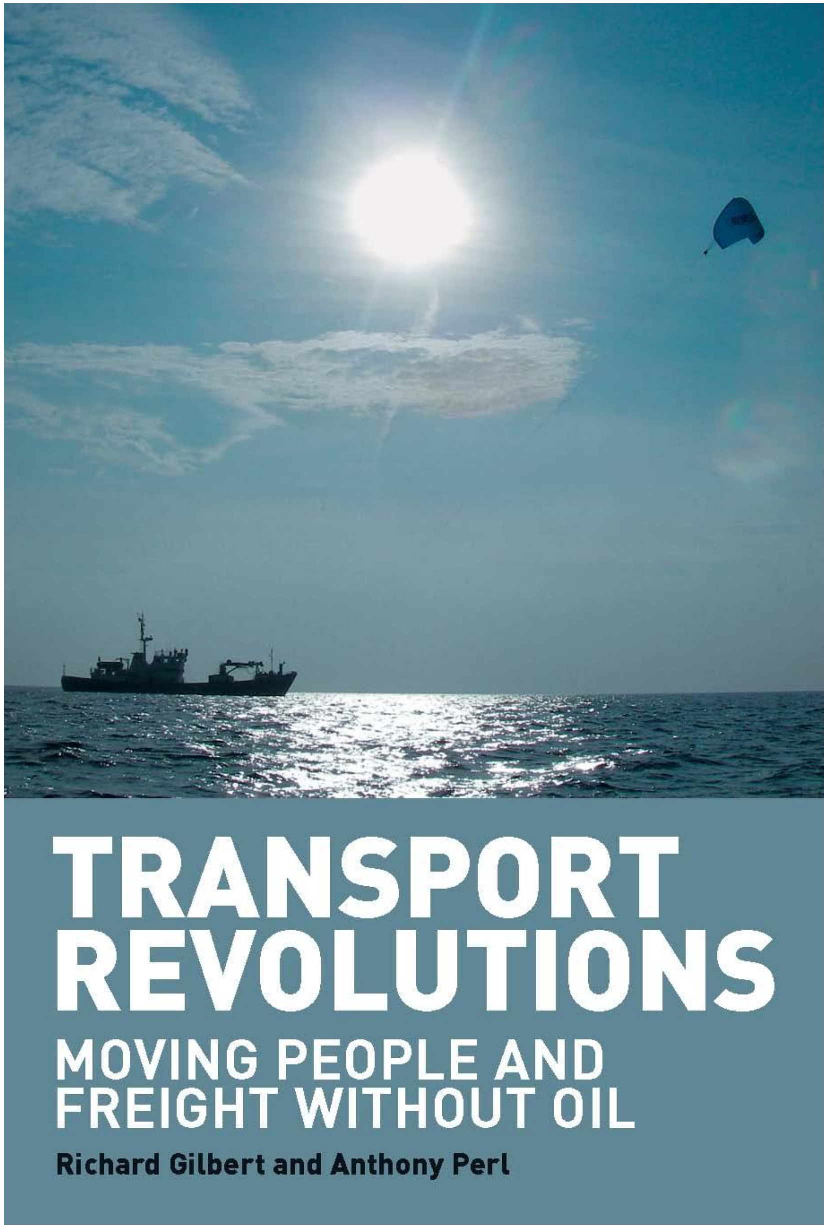
Launching Transport Revolutions in China 2

Nevertheless, there can be some reason for hope for timely transport redesign in China:

- ‘Eco-cities’ have their highest expression in China; Dongtan is the best known among many that exploit the rapid pace of urban development to achieve high-quality living using only renewable fuels.
- In December 2007, the Government of China issued a white paper on energy policy and set up a high-level body to oversee energy issues, partly in response to deep concern about oil availability and use.
- Fuel prices in China are relatively low, offering scope for reducing consumption or raising revenue for transport redesign, or both.
- China is rapidly implementing the world’s most ambitious programme of rail expansion and electrification.
- China has a huge potential to generate electricity renewably; e.g., off-shore wind, desert solar thermal.

2008 could be a critical year

- If transport redesign is to be well under way by 2025 it should start by 2010 and attitudes should begin to change during 2008.
- One tipping point could be Saudi Arabia's failure to raise oil output, confirming suspicions that her oil production has entered depletion.
- Another tipping point could be a crisis in the aviation industry drive by high prices for jet kerosene.
- The US elections in November, and the campaigns for them, provide extraordinary opportunities to begin changes in direction.
- As for Japan at Tokyo (1964) and South Korea at Seoul (1988), the Beijing Olympic and Paralympic Games will be China's 'coming out', in this case as a superpower.
- A natural arena for China's leadership will be oil geopolitics, perhaps expressed through promotion of an Oil Depletion Protocol.



MANY THANKS FOR YOUR INTEREST!

For more information about *Transport Revolutions* visit www.transportrevolutions.info

For more information about Richard Gilbert visit www.richardgilbert.ca

ADDITIONAL SLIDES

(used in some discussions)

Oil Depletion and Anthropogenic Climate Change 1

- These are complementary issues demanding similar remedies.
- Preparations for oil depletion mostly concern motorised transport. (Worldwide, 55-60% of oil is used for transport, which is 95% fuelled by oil products.)
- Climate change could have more long-lasting, widespread, and profound impacts than oil depletion.
- The impacts of oil depletion—chiefly high pump prices for transport fuels—could be more imminent and the need to address oil depletion could be seen by the public as more compelling.

Oil Depletion and Anthropogenic Climate Change 2

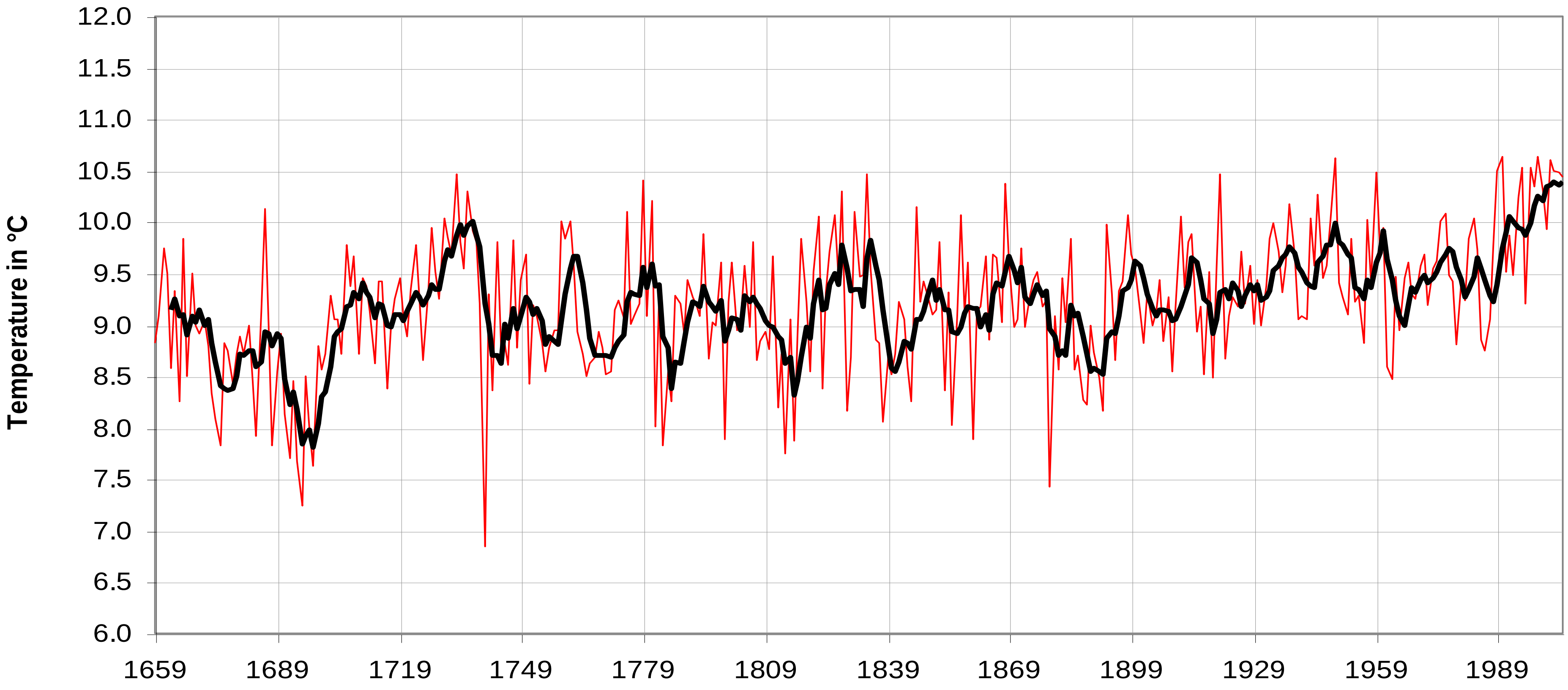
- At the Swiss Energy Conference on January 14, European Energy Commissioner Andris Piebalgs spoke on strategic challenges in energy policy-making.

- He noted the importance of addressing climate change, adding that "in the shadow of this challenge is a second issue that has been ignored … the so-called 'peak-oil' problem … when oil production rate begins to fall while demand continues to rise naturally".

- He continued, "Just as with climate change, there is nothing in our history that has prepared us for such a development. … I do not believe we can take the chance [of allowing demand to run ahead of dwindling post-peak supply]".

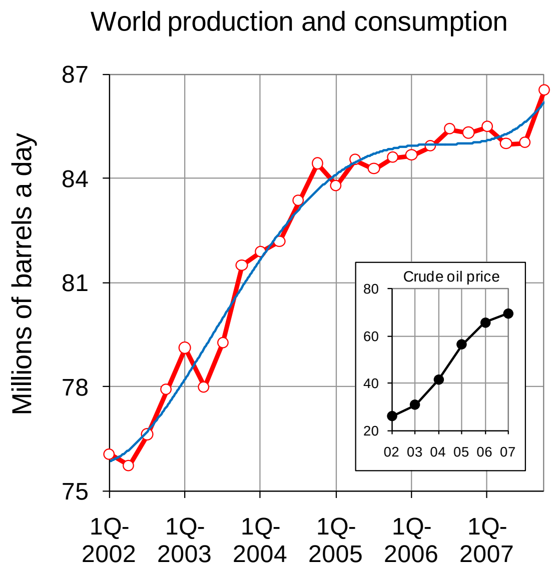
Focusing on oil depletion is not the same as denying anthropogenic climate change

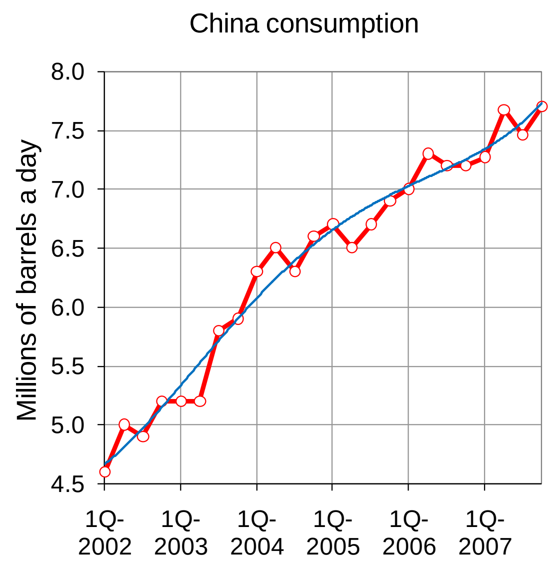
There is little doubt that climate change is happening. Below is the Central England Temperature Record, the world's longest set of readings of surface air temperature by thermometer. (Does the 20th- and 21st-century rise at least partly reflect microclimatic effects of socioeconomic activity?)

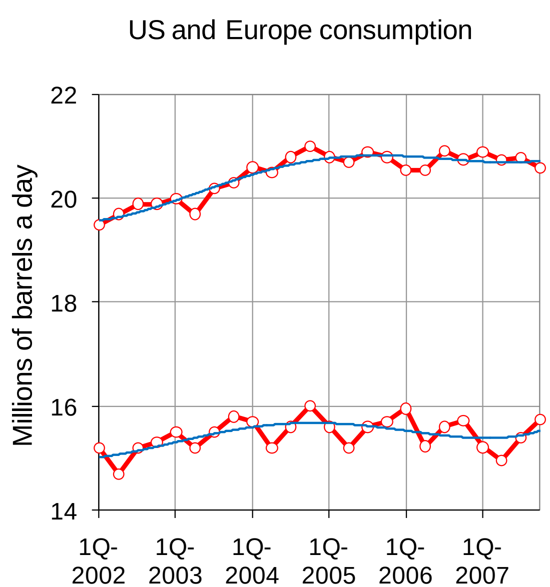


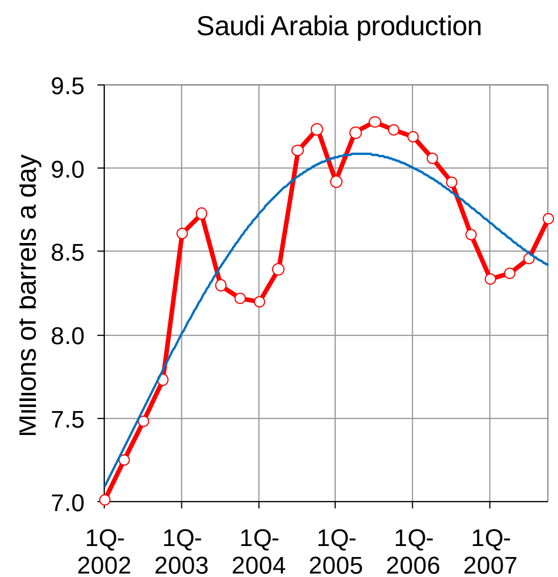
The thin line joins annual averages from temperature stations. The thick line joins five-year moving averages of these averages.

Current trends in oil production and consumption





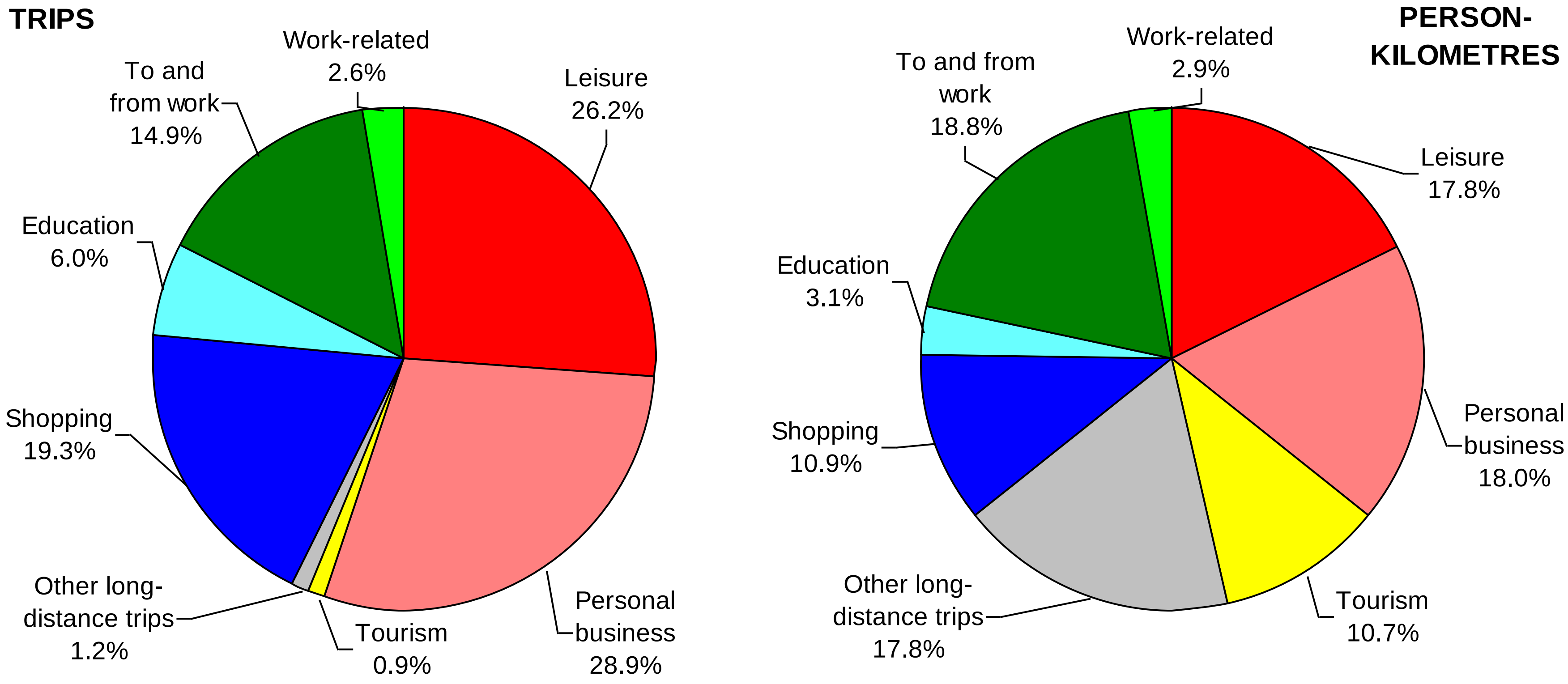




Note: Trend lines are fourth-order polynomial.

Trip purposes, movement of people, U.S., 2001

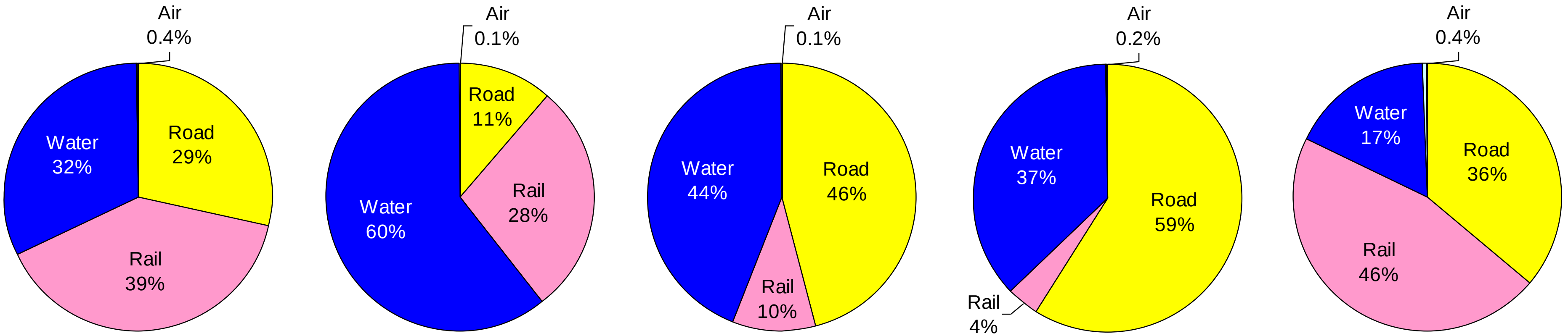
The chart on the left shows the movement of US residents in terms of *trips.* Note the low commuting shares. The right-hand chart shows the same thing in terms of *person-kilometres*. Data for UK residents are essentially similar, except that shorter distances are travelled, particularly for education and personal business.



Source: US Bureau of Transportation Statistics (2006)

Domestic movement of freight by mode, several countries, 2003-2005

Each pie chart shows for one country for one year how *domestic* freight movement is shared among air, rail, road, and water modes. Below each chart is the amount of domestic freight movement *per capita* in tonne-kilometres (one tonne of freight moving through one kilometre). Similar pie charts for *interna-tional* freight transport would be almost entirely blue (for marine transport), even for Europe.



Canada, 2004 *(25,810 tkm/pers.)*

China, 2004 *(5,280 tkm/pers.)*

Europe (EU25), 2005 *(8,160 tkm/pers.)*

Japan, 2005 *(4,470 tkm/pers.)*

U.S., 2003 *(17,520 tkm/pers.)*

Sources: Natural Resources Canada (2006); National Bureau of Statistics of China (2006); European Commission (2006); Ministry of Land, Infrastructure and Transport, Japan (2006); US Bureau of Transportation Statistics (2007)