

Transport and adaptive capacity: An integrated approach to UK policy evaluation

2500 words

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Central findings

- Transport policy needs to be integrated into other policy areas, especially energy security, public health and community links if it is to adapt to climate change.
- Physical and technological limits to change must be considered before creating transport policy to adapt to climate change.
- The UK's existing transport system is vulnerable to climate change and peak oil. Considering only climate change may result in ineffective policy.
- Physical risks threaten the transport infrastructure of the UK. New light railways, walkways and bicycle paths should be located above flood plains
- Economic risks can be overcome by a move towards non-motorized transport
- Social risks include the possibility that people are unwilling to adapt. Plans must be made now to allow a smooth transition away from the car.
- Climate change offers a unique opportunity to improve the UK's transport policy.

- **The central message is that transport policy must focus on simple technologies that are proven to work on a large scale today.**

Report submitted to Professor Mike Ashmore as part of an MSc degree in Environmental Science and Management. This report will also be submitted Hugh Bailey MP who has an interest in transport policy.

1 Introduction

1.1 Why this report is needed

There is an ongoing political furore over the future of the UK's transport policy. Debates rage over the third runway at Heathrow,¹ EU vehicle emission targets,² and recently (March, 2009), a cost-ineffective plan to subsidise car disposal.³ Each of these debates can be seen as the clash of two incompatible paradigms.⁴ The growth-orientated, fossil-powered transportation industry is one paradigm. Supported by some powerful politicians (notably Lord Mandelson), it portrays the fuel-intensive transport sector as 'vital for the economy'.⁵ The 'sustainable mobility paradigm' is the other (Banister, 2008). This paradigm demands the transformation of the transport sector in order to achieve a range of goals: mitigate climate change,⁶ prepare for peak oil,⁷ improve the UK's health (NHS, 2005) and recreate social networks.⁸

Despite a diverse literature from both camps, relatively little has been said about the transportation sector and adaptation to climate change. Government literature on the subject is totally inadequate.⁹ This report was written primarily to further my own understanding of transport policy. I hope that the information below leads people to reconsider the sustainability¹⁰ of their own means of transport and move the political debate forward, if it is ever made available to a wider audience.

This essay aims to show how the UK's transportation system can adapt to climate change.

To do this, we need to what the effects of climate change and related phenomena will be. By 'related phenomena' I mean peak oil, market volatility and the repercussions of these problems. For too long climate change has been viewed in isolation from parallel phenomena that may be equally important to human wellbeing.

For example, analyses that ignore resource depletion may recommend resource-intensive solutions to climate change, such as personal flying machines,¹¹ electric cars,¹² or regional CCS schemes. In the light of 21st century resource depletion, such recommendations would not only be misguided, they would be dangerous.

Because of this danger, adaptation of the UK's transportation systems to climate change is discussed in the context of wider social and economic change. 'Climate change' is henceforth used to mean climate change and related phenomena. We live in an interconnected world, so lateral thinking, as advocated by DeBono (1970), is used throughout. In light of the above, the objectives of this essay are:

Section	Objective
2.	to understand the risks posed to the UK's current transport systems
3.	to find and expand upon opportunities to the UK's transport system that may be beneficial to the UK population
4.	to recommend potentially successful pathways of adaptation

1.2 A reality check

“For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled.”
Richard Feynman

Before analysing future changes in the UK’s transportation sector, it is important to understand the current system. Consideration of physical and technological limits will focus attention on the more realistic options available. It would be nice, for example, to consider flying cars, hydrogen-powered bicycles and solar powered trains. This reality check section will filter out such extravagant ideas at the first hurdle. Ink is conserved for policy-relevant options that have a real chance of success.

The current transportation system has become dominated by the personal automobile (Figure 1).

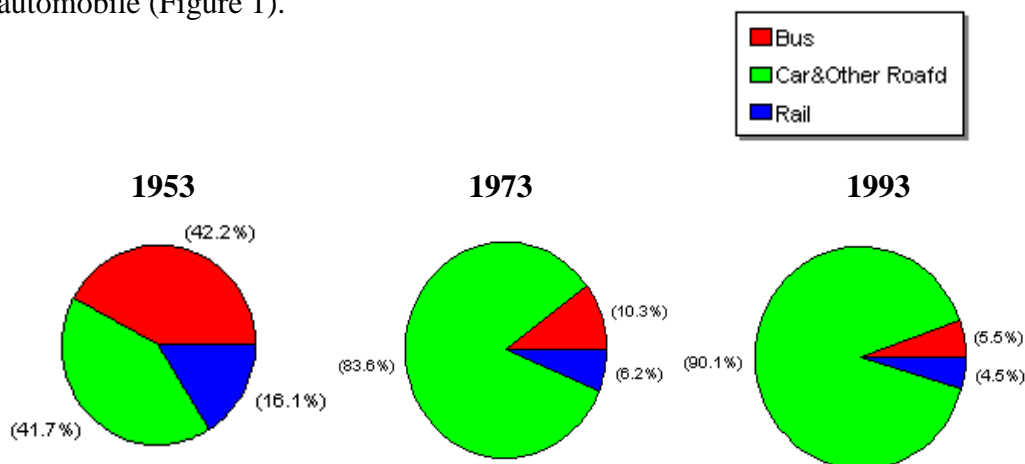


Figure 1: Percentage of passenger miles travelled by car, bus and rail between 1953 and 1993 (DfT, 1995). The car has gobbled up other forms of transport in the UK over the last 50 years. Note, the current distribution of motorized travel usage would be very similar to that of 1993.

Not only do cars transport UK citizens over a larger distance than any other form of transport – 4×10^{11} passenger kilometres, or 88% of the total – (CFIT, 2007). The transport infrastructure of every city, town and village (to my knowledge) is designed around the car. Car ownership is 38% in the UK, compared with 1% in China, and 48% in the USA (LivingSpace, N.D.) Car occupancy in the UK is 1.58 (DfT, 2008), slightly higher than other European countries. The percentage of passenger miles travelled by car in the UK is high compared with EU data; the percentage of miles travelled by foot, bicycle, tram and bus is relatively low in the UK (Figure 2).

Obesity, caused partly by car dependence (Wen et al. 2006), could cost the UK £45 billion per year by 2050 (Foresight, 2007). Adaptive capacity depends on the nation’s baseline health levels and community interconnection (Fussel and Klein, 2006; Heltberg, 2009). Therefore car dependence can be seen as an important barrier to adaptation.

The aviation industry in the UK is one of the most developed in Europe (CFIT, 2007). Britons fly more frequently than almost any other citizens on Earth, which acts against the build-up of community links and may increase social isolation (Gössling, 2002). Community links make a country resilient to any stressor, including climate change.

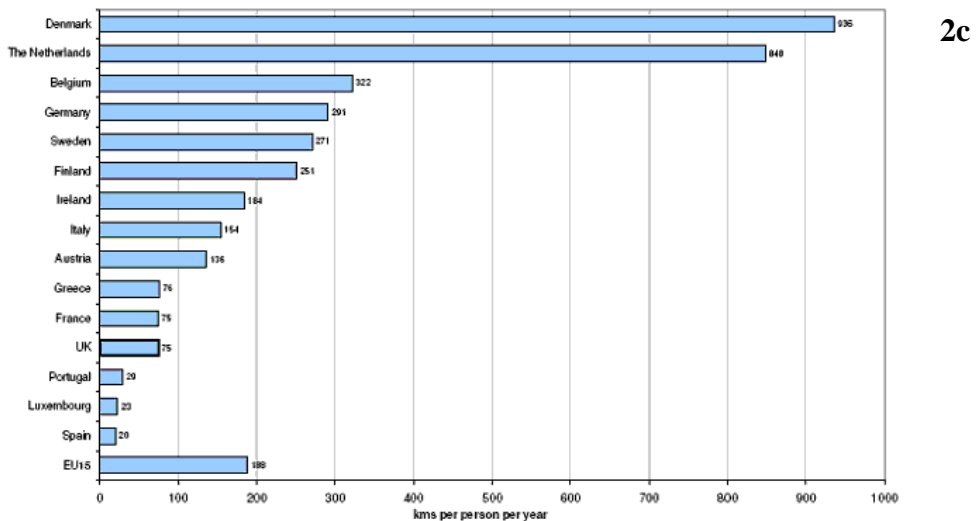
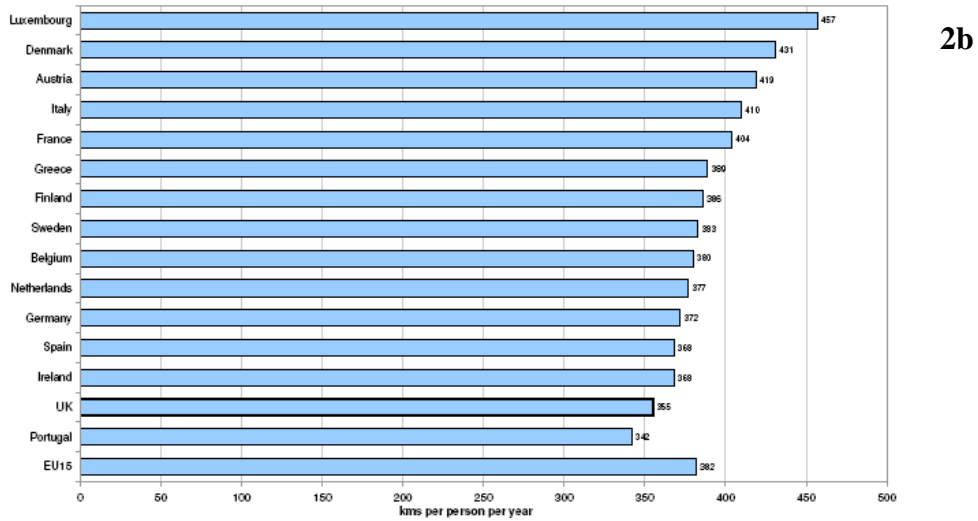
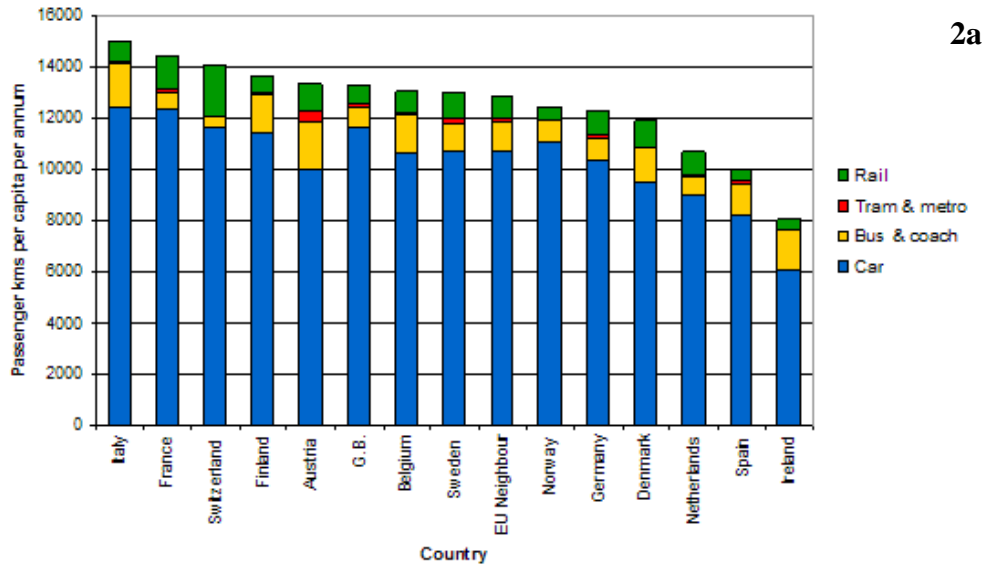


Figure 2: Distances travelled by car, bus, rail, tram, foot and by bicycle per capita in a selection of EU member states (CFIT, 2007). Figure 2a is restricted to motorized transport. Figure 2b and 2c are restricted to walking and cycling respectively. The reliability of the data in Figure 2b and 2c is debateable (CFIT, 2007), but is the best available. Note the distance travelled by motorized transport is over an order of magnitude greater than the distances travelled by sustainable transport in all countries. Note also that the UK is more car dependent than all other countries on the graph.

Physical limits cannot possibly be broken. It is important to consider physical limits to avoid wasting resources on projects that are destined to fail.¹³

Resource constraints, especially peak oil, will be the most important set of physical limitations imposed on the UK's transportation sector (Appendix 1). With this in mind, the increasing share of the UK's energy budget consumed by transport is especially worrying (Figure 3).

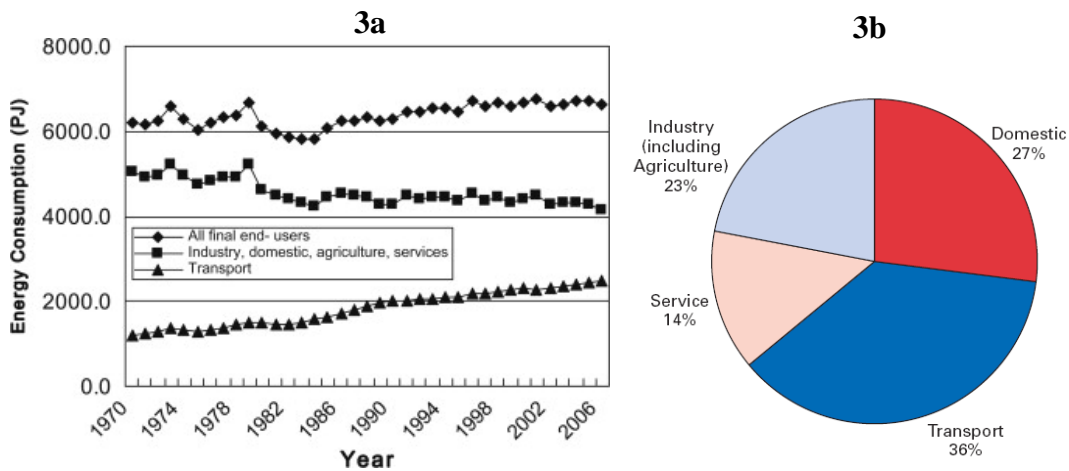


Figure 3: Energy consumption by the transport sector. 3a shows energy consumption by end-user in the UK between 1970 and 2006 (Gasparatov et al., 2009). Transport has progressively burned more high quality fuel as other sectors' energy use remains constant and even as efficiency improves. 3b shows predicted final energy usage in the UK in 2010 (BERR, 2007). This scenario shows the trend is expected to continue. The transport sector is will use up 36% of all energy used in the UK in 2010, compared with 34% in 1990. Some of the energy currently burned by the transport sector could be used to help other sectors adapt to climate change.

21st century resource depletion means that some of the complex technologies touted as 'solutions' to peak oil (e.g. biofuels,¹² electric cars,¹¹ and hydrogen cars¹⁴) cannot be effective at the global level on the timescale required and will not be considered further.

Technological limits can be overcome by research. Unfortunately, the timescale between drawing up an idea, and putting it into production is long. Energy systems are subject to an especially high level of inertia and have historically adapted only on inter-decadal timescales (Smil, 2008a). By focussing attention on simple, low energy technologies that already work (e.g. walkways, rickshaws, bicycles, and buses), government and industry can avoid wasting scarce resources.

In the long term, complete decarbonisation of the transport sector is necessary as fossil fuels will become depleted over the 21st century (Smil, 2008b).

1.3 What do we want from the transport sector?

The government's transport bureaucrats, (e.g. UKCIP, 2007; DfT 2007), appear to see the sole goal of transport as the moving individuals from one place to another. However, the transport system is more than an array of individual teleportation devices: it is the fabric of our social space (Illich, 1974).

Based on the knowledge that transport provides a wide range of services (and disservices) beyond individual mobility, Doll (2008) believes the transportation sector should have the following goals:

1. Financial viability
2. Congestion mitigation
3. Safety
4. Noise reduction
5. Air quality
6. Climate protection
7. Nature conservation

Given that integrated policy is needed to enhance societies' adaptive capacity, (Fussler and Klein, 2006), each of Doll's 7 goals can be considered a goal towards adaptation. Notably, 'climate protection' is here classified as adaptation. This is because adaptation will only be possible if climate change does not exceed a certain level of severity (explained at length in IPCC, 2007, Ch. 18; or succinctly in Monbiot, 2009b). Therefore a whole range of factors add to a society's adaptive capacity. Because of this, I would like to add some additional goals to the 7 identified above:

8. Energy security
9. Social cohesion
10. Public health

1.4 The impacts of climate change

The impacts of climate change in the UK are relatively well known compared with our state of knowledge of peak oil. We know:

- Intense rainfall events will become more probable
- Temperature ranges will change
- Sea level will rise and storms are likely to become more intense

Less is known about the impacts of peak oil as less academic work has been written on the subject. An interesting new branch of human endeavour investigates the interaction between peak oil and climate change (see Ecodyfi (2009) for a local example from the Welsh Valleys, or Bardi (2009) for a neat summary of what is being published in academic journals). Two phenomena that recur in the peak oil literature:

- Oil prices will become increasingly volatile
- Financial institutions will collapse

The social impacts of the above changes can only be speculated. Some predict the uptake of simpler lifestyles; others a resource grab.

2 Risks to the current transportation sector

“A people can be just as dangerously overpowered by the wattage of its tools as by the caloric content of its foods, but it is much harder to confess to a national overindulgence in wattage than to a sickening diet.” Ivan Illich

2.1 Risks from the physical impacts of climate change

Changes in the parameters that define our climate will pose risks to UK transportation systems:

- Increased frequency, duration and intensity of heat waves and floods pose problems to bridges, roads and other transport infrastructure.¹⁵
- Car accident frequency is likely to increase due to both increased maximum temperatures (Stern and Zehavi, 1990) and increased winter rainfall (Satterthwaite, 1976).
- Increased winter-time rainfall may cause increased flooding of roads and railway track. Hundreds of miles of road and rail were impassable during the floods of summer, 2007 (RMS, 2007). Other problems were that:
 - Thousands of cars were left stranded in the water, further disrupting roads
 - Not only were roads and railways impassable, some were permanently damaged by the flooding (Figure 3)
 - Floods more severe than those of 2007 will pose a serious threat
- Transport hardware will be exposed to increased risk from flood damage as garages, bike shops and bus and train depots become inundated

2.2 Risks from the economic impacts of climate change

By 2050, conservative estimates (Stern, 2006) suggest that 3% of global GDP could be erased by the effects of climate change. Since the report, Sir Nicholas Stern has stated that impacts were “badly underestimated.” Combine this with the economic effects of peak oil and the current global depression and it becomes clear that the UK’s economy may be unable recover in the next decade, if at all. This will pose various threats to the transport sector, including:

- Another ‘oil shock’ could induce the haulage industry to strike as it did in 2008. Combined with other problems, this could lead to food shortages in some parts of Britain
- Oil price shocks could leave car-dependent families and businesses stranded, while import restriction could leave petrol stations dry.
- Planned investment in transport infrastructure may be cancelled as liquid capital dries up.

2.3 Risks from the social impacts of climate change

Economic turmoil could lead to social turmoil. A worrying possibility is that instead of adapting by finding new forms of transport, people will simply give up and decide that we are 'doomed'. Worse, people may assume that new tribes will form based on race or ideology and that internecine conflict will inevitably ensue. Such pessimistic fatalism poses a significant risk to the sustainability (capacity to adapt) of the UK's transport system.

- There may be a switch in attitudes from 'there is no problem' to 'we are all doomed'. The lack of middle ground between these positions may act to prevent people adapting to new transport systems.
- The problems of addiction and obesity associated with an oil-rich lifestyle may be exacerbated by peak oil. People may become depressed and simply increase their vice-dosage of food, alcohol, porn or television. This type of behaviour may prevent people taking up more efficient, adaptable forms of transport.
- People in a position to help others adapt to new transport systems (e.g. bike mechanics, coach-company operators, politicians) may be unable to act, due to the prevailing socio-economic circumstances.

3 Opportunities

“In Chinese the word crisis is composed of two characters. One represents danger, and the other represents opportunity.” **John F. Kennedy**

3.1 Opportunities arising from the physical impacts of climate change

While winters become wetter, summers are projected to become warmer and dryer (UKCIP, 2002). This presents a significant opportunity for sustainable travel – walking and cycling. One of the major attractions of the personal automobile is that it keeps people warm and dry when the weather is cold and wet. Warmer summers could remove the one of excuses people offer for not travelling by bike or foot.

The flood risk to low-lying roads and railways provide a strong incentive to invest in new transport infrastructure, located away from coastlines and floodplains. This presents the opportunity to build new infrastructure that caters better for the needs of the 21st century. Walkways, bicycle paths, light rail and trams could be constructed in areas safe from the flooding threat. The larger of these plans (railways and trams) rely on the assumption that there will be capital and fossil fuels available. As discussed above, this assumption may not hold.

Bike paths and walkways, however, are an order of magnitude cheaper than roads and railways in energy and monetary terms. By investing in bike paths and walkways, the government would also promote a healthy, and therefore resilient, population. This is an important aspect of adaptive capacity (IPCC, 2007, Ch. 18).

3.2 Opportunities arising from the economic impacts of climate change

The economic outlook described above is indeed grim. However, the lack of money in the system may provide a unique opportunity for people to admit the shortcomings of the current set-up.

Already, the uptake of cycling for economic reasons has soared. Continued economic strife could lead a significant proportion of the population to ditch the car in favour of more healthy alternatives. This shift to walking and cycling would increase the adaptive capacity of the UK in terms of: health, community ties and energy security.

The government takeover of the banks may create investment opportunities for the greater good. Schemes such as safe walkways and cycle routes above floodplains rely on such government funding. Investments in coaches and trains, which have been recommended to adapt to peak oil by Monbiot (2006), could be made available through these new government-owned banks.

3.3 Opportunities arising from the social impacts of climate change

The future shifts in public attitude that will accompany climate change cannot be known. However, several analyses have suggested that the voluntary uptake of simpler lives will be an important trend of 21st century society. This trend would be conducive to adaptive change in general, and especially in the transport sector where a car can often be easily be exchanged for bicycle.¹⁶

4 Recommended pathways of adaptation

It is now clear that we need an integrated climate policy that tackles the range of problems that we face in the 21st century. A series of isolated and incompatible plans for each UK policy area is of little use to policy makers. How, for example, can agricultural policy ignore biodiversity policy?

Throughout this essay, it has become apparent that transport policy is intimately linked with other policy areas, notably: energy security, health and local government and communities. Each of these policy areas is vital for adaptation to climate change. Recommendations are thus broad (with a few concrete examples provided to illustrate the idea).

Key:

- General policy aim
 - Objectives: how the policy aim can be achieved
 - Concrete examples

- **Transport in the UK should become less oil dependent.**
 - Government shows UK citizens that the era of car dominance is over.
 - An expansion of the London congestion charge (which generates £120 million per year) to all major cities
 - An increase in the spatial and temporal coverage of car free zones in city centres
 - Government subsidies made available to car companies that expand into domestic bicycle manufacture
 - Subsidies to trade one's car for a bicycle
 - The government should discourage air-travel
 - New airport expansion plans halted
 - Kerosene used in jet engines taxed at the same level as petroleum used in cars.
 - Accelerate the fuel tax escalator.
 - The government should encourage sustainable transport
 - A ministry of sustainable transport (MOST) should be formed to integrate the development of the UK's walkways and cycle paths with public transport systems. It should receive more funding than the DfT.
 - Cycling should become part of the national curriculum by integrating it with existing P.E and citizenship classes
 - The government should encourage public transport
 - New light rail and tram systems should receive investment instead of roads
 - An intercity coach system should be set up, and dedicated coach lanes should be created on motorways (thanks to Monbiot, 2006 for this idea)

- **The UK's transport infrastructure should be made more resilient to climate change.**
 - New infrastructure should be built above floodplains and away from the coast.
 - A national plan to assess the impacts of climate change on bridges should be conducted
 - Existing infrastructure should be 'climate proofed'

- **Simple and effective transportation technology should be pursued through science**
 - Innovative ways to manage the flows of buses, cars, bicycles and pedestrians through urban space should be funded.
 - Funding should be directed towards traffic light systems that give priority to buses, pedestrians and cyclists over cars.
 - The bicycle industry should be encouraged to make cycling more accessible, practical and fun. Subsidies should be available for:
 - The design of comfortable and stylish bikes by UK companies
 - Pannier, rickshaw and trailer development
 - New cycling sports

If each of these recommendations is implemented, the broad goals of transport policy (identified in section 1.3) will be easier to meet.

5 Conclusion

The central message is that the focus must be on technologies that are proven to work today.

A complete restructuring of the UK's transportation sector is needed to increase the adaptive capacity of the nation's means of transport, economy and society. In the context of climate change and peak oil, current government policy amounts to a cornucopian faith in unproven technology and wishful thinking regarding fuel supplies.¹⁷ If politicians follow outdated transport policies until the bitter end, they lock future generations in to a system that will collapse.

Fortunately, integrated approaches to transport are more appealing than the fossilised approaches they replace. The wide range of actions that could be taken includes measures that simultaneously create jobs and exportable industry, reduce energy dependence, increase public health and recreate broken communities. Action can be taken at many scales, and not just through the national government. The road ahead will be rocky, but it is certainly not impassable or totally new.¹⁸

* * *

Returning to the political furore mentioned in the introduction, this essay can now contribute to the debates. It is clear that the industrial car-based model cannot achieve the goals of transport policy in *current* atmospheric conditions, let alone in the future. Banister's (2008) 'sustainable mobility paradigm' needs to be put into action now. This essay simply gives some starting ideas.

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7 Appendices

Appendix 1: Energy constraints on the UK's transportation system

Global production of oil peaked in July 2008¹⁹ and, due to price volatility and the large number of drilling projects that have recently been abandoned,²⁰ is probably on a slope of terminal decline. The decline rate of global oil production may be rapid (~5%) between 2010 and 2015 as large oil fields become depleted. Other analyses suggest slower rates of decline. (Figure 3)

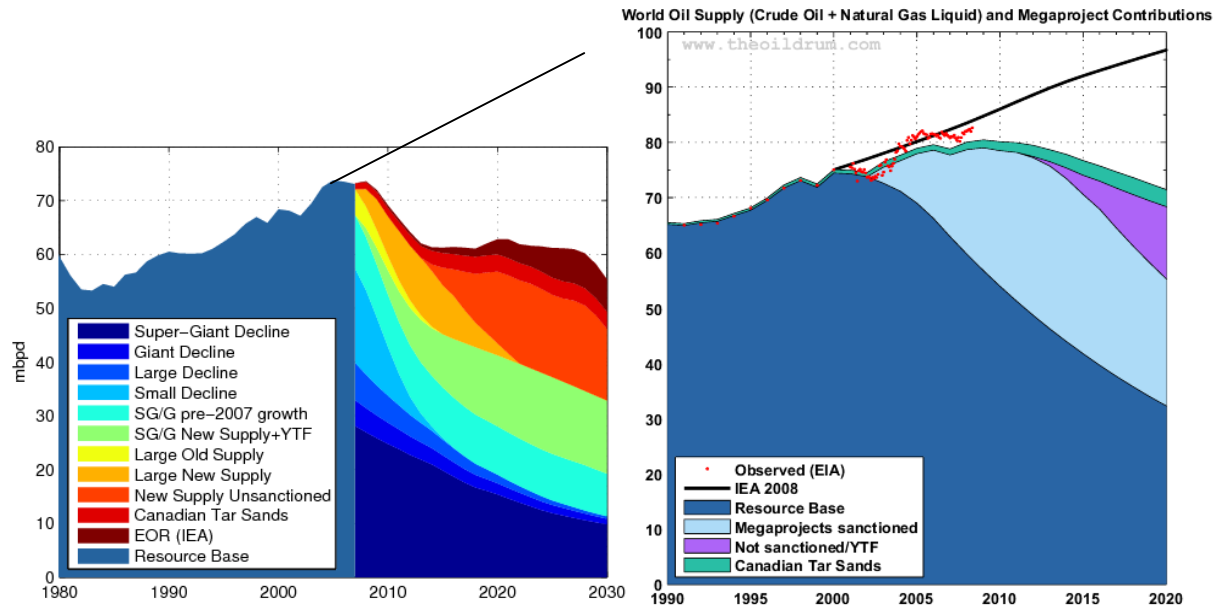


Figure A1: Recent projections of global oil production in the coming decades based on data of decline rates and EIA data for past output. Note the optimistic EIA projections (the black lines). 3a is the result of a detailed mathematical model by Foucher (2009). 3b is the result of a model by Eriksen and Foucher (2008). Regardless of the exact of shape of the decline curve, which depends to a large extent upon socioeconomic factors which cannot be modelled, it is clear that that unless the UK increases its share of global oil consumption, there will be less fuel available in the UK in the near future.

The above indicates that transportation systems must adapt to climate change *and* peak oil, starting now. The influential Hirsch Report, written for the US government, recommends that planning for peak oil needs to begin 20 years before the event. This means the UK's transport system needs to rapidly wean itself off oil now. In the long term, complete decarbonisation of the transport sector is necessary as fossil fuels will become depleted over the 21st century (Smil, 2008).

Against this backdrop of oil depletion, the transport sector has consumed a growing fraction of the UK's total energy budget (Figure A2)

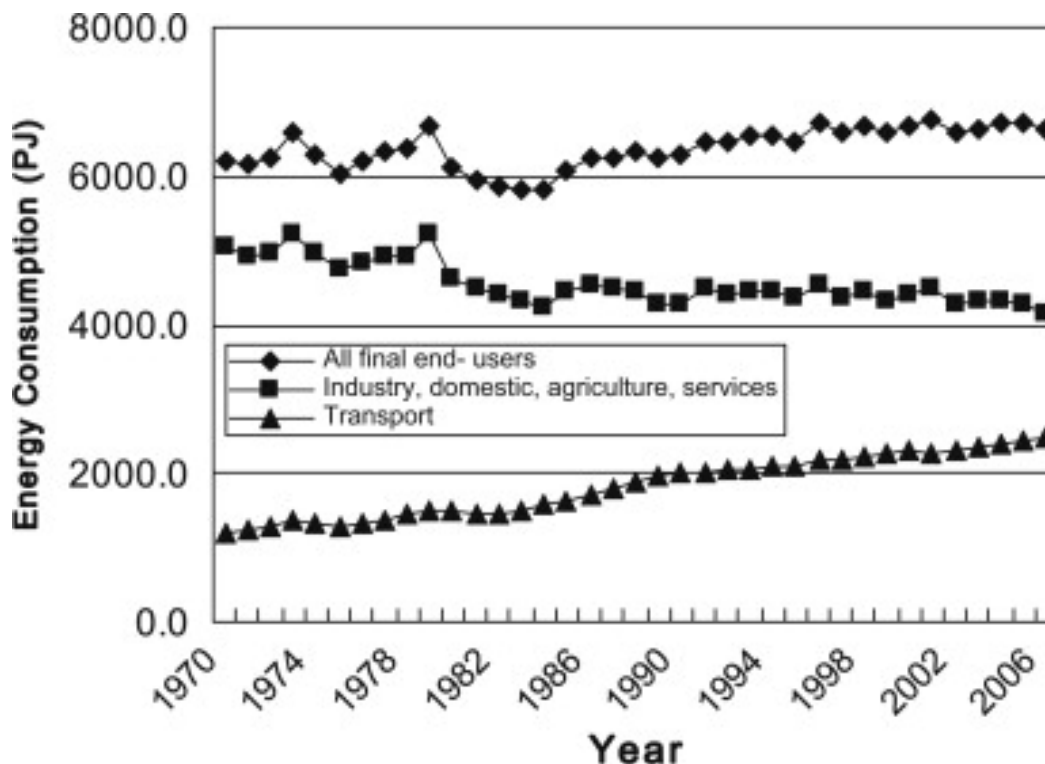


Figure A2: The transport sector's consumption of energy compared with that of other sectors

The amount of energy available to the UK is large compared with the amount of energy that the transportation sector consumes $>2 \times 10^{14}$ KWh are available from sunlight.²¹ However, only a fraction of this energy can be harvested.

The low efficiency of photosynthesis ($<2\%$), and the need to use land for agriculture and wildlife in a time of food insecurity, land-based biofuels are not an option.⁸ Electric cars cannot realistically replace traditional cars as the national grid comes under pressure from climate change and resource depletion. Hydrogen cars have little chance of success, as their production requires vast quantities of platinum and energy.

Appendix 2: Local politicians to whom this report will be sent

1. Hugh Bayley MP: Labour MP for York, City of bayleyh@parliament.uk
Who recently said: "I want to explore some ideas about the role that our railways could play to help our country out of recession.... they carry more passengers now than at any time since the second world war. "

2. Bill Wiggin: Conservative MP for Leominster
Who voted strongly for action on climate change
Leominster Conservatives
8 Corn Square
Leominster
Herefordshire
HR6 8LR

3. Stephen Williams MP: LibDem for West Bristol
Who voted strongly for action on climate change

stephenwilliamsmp@parliament.uk

8 Endnotes

¹ Strong disagreements within the Labour party led two MPs to resign in protest of the government's decision to go ahead with Heathrow's third runway. Labour may have lost the vote were it not for the immense pressure put upon MPs: "government whips were piling pressure on Labour MPs and were flying some of them back from Strasbourg, ... to vote for a third runway" (BBC, 2009).

² The UK's Department for Transport (an organisation that is supposed to support the public's interest), along with corporate lobbyists, pressured UK MEPs to water down the EU's proposal to limit emissions from cars to 120g of CO₂ for every kilometre travelled by 2012 (Young, 2008).

³ Monbiot (2009) shows how carmakers are now trying to increase demand for new cars under the cover of a 'green' policy which, the evidence suggests, would be harmful for the environment. Under the new policy, car-owners would be encouraged to driving by being offered cash rebates for scrapping old models in favour of new models.

⁴ In this context the word 'paradigm' means "a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them" (<http://www.thefreedictionary.com/paradigm>). Graham and Shaw (2008) see the debate over airport expansion as the clash between incompatible groups with their incompatible aims being: continued growth vs environmental sustainability. The same concept has been expanded upon here to apply to the wider debate over a range of transport-environmental issues.

⁵ Central government has stated that fossil fuel-powered transport is "vital for the economy" on various occasions (e.g. DfT, 2004) who states: "Many businesses that rely on air transport are hi-tech, knowledge-intensive sectors such as banking and finance, research and development and IT, which are all vital to our future economic growth and prosperity." BMW's "education programme" claims that "Transport is vital for the economy, which depends on our ability to move goods from where they are made to where they are used, swiftly and reliably" (BMW, 2008). Note the use of colloquial evidence in their claim.

⁶ Two examples out of a thousand include are Welsh Assembly (2008) and Hillman (2006).

⁷ In academia, Emberger et al. (in press) conclude that peak oil should be considered in transport policies in Europe and Asia. Because of peak oil, they recommend the transformation of transport policy: "The present set of policy instruments used in South East Asian cities should be extended and should not to be too narrowly focussed upon infrastructure provision for car users. Mass transport and the promotion of non-motorised modes need to be given more weight to solve present and future transport challenges especially in the light of the vanishing fossil fuel supply (Peak Oil, 2008 Peak Oil, 2008 <http://www.peakoil.com/>.Peak Oil, 2008)." However, peak oil has not generally been the primary concern of those wanting to change transportation. Exceptions include the analyses of transport published on The Oil Drum, and WWF (2008).

⁸ A friend of mine, Joshua Hart, conducted a dissertation on the social impacts of local transport systems. He found that busy roads lead to social isolation. His work is neatly summarized in Vidal (2008). The solution is a transformation of the transportation systems. The NHS (2008) and Illich (1974) advocate the same thing, but in very different ways.

⁹ The report offered on UKCIP's website (UKCIP, 2007) was simply the minutes from a workshop held on climate change written up and given an introduction. This report offered no concrete policy measures, assumed that all transport was motorized (walking and cycling were not even mention). Obscure, impenetrable language was used throughout (e.g. one conclusion read: "the presentations at the workshop indicated the high-level of expertise and knowledge of climate change impacts and adaptation response..." this is meaningless garbage). In the author's opinion, the present report should be on the UKCIP website, not UKCIP (2007). Another official government response (DfT, 2007) is ugly, bureaucratic, and incapable of systems thinking. The report does not mention the impacts of transport on health, community links and totally ignores sustainable forms of transport (cycling and walking) from the analysis. The words 'cycle' and 'walk' appeared nowhere in the document. The risk identified are trivial compared with the scale of the risks (e.g. Leaves on the track, from prolonged

growth periods) and there is no integrated transport planning. The most worrying aspect of government literature on climate change and transport is that it seems to be totally unaware of peak oil. **It is therefore my opinion that the UK's transport policy is ensuring disaster with its current transport policy.**

¹⁰ By sustainability, I mean “the capacity to create, test and maintain adaptive capacity.” In practice, this means creating a system that doesn't collapse (Holling et al., 2002)

¹¹ The BBC, of all organisations, has fallen for the idea of personalised flying machines, (see BBC 2004, 2008). The limitations of such schemes are left to the reader's imagination, assuming the reader has an imagination. Although amusing in the short term, the BBC articles reveal a systematic problem with mainstream opinion and media:

¹² Many in the car industry and in large environmental NGOs (notably WWF, 2008) have promoted electric cars as a solution to climate change and resource depletion. However, sober analyses based on science (e.g. *Vaughan, 2009*; Granovskii et al. 2009) show that electric cars simply shift the environmental problems elsewhere. This ‘problem shift’ is something that appears frequently in technological solutions to environmental problems (Goodstein, 2005).

Granovskii et al. (2009) conclude that: “if electricity comes from fossil fuels, the electric car remains competitive only if the electricity is generated on board.” Given that the UK's electricity comes primarily from coal and gas, battery-powered cars would not be competitive. On-board generation makes electric cars larger, heavier, more complex, more resource intensive to produce, and more expensive. While I concede that electric cars have some use when there is ample electricity supply (e.g. in Norway), in the UK there is looming gap in electricity-producing capacity. When blackouts and shortages are on the cards, as they may be, the last thing the National Grid needs is another diffuse load on the system.

¹³ Pimentel and Patzek (2005) demonstrate that corn and soy based biofuels are ineffective due to physical constraints: “Several physical and chemical factors limit the production of liquid fuels such as ethanol and biodiesel using plant biomass materials.” The physical limiting factors include the fact that: “On average the sunlight captured by plants is only about 0.1%, with corn providing 0.25%.” It could be argued that if physical limits were considered early on, the disastrous domestic biofuels target (5% by 2010) would never have been set (Monbiot, 2008).

Some biofuels may become feasible if the technological constraints to converting cellulose to ethanol are overcome (Gossop, 2006), and if the need to maintain soil-carbon content is ignored.

¹⁴ Global platinum production, an essential element for large-scale deployment of hydrogen-powered cars, (and fossil-powered cars) will reach a bottleneck within the decade according to Yang (2009), writing in the prestigious *Energy Policy*.

¹⁵ Civil engineers designed these structures to work in the current range of temperatures. Flooding has historically been associated with bridge damage and destruction, at least in Chicago (Changon, 1999). Common sense says that this trend also applies in the UK and is likely to continue. Also tar melts, expansion of large metal girders beyond their designed range due to thermal expansion and road disintegration due to flooding are also serious risks.

¹⁶ Here I rely on my personal experience. Growing up in the countryside 12 miles from the city of Hereford, I was totally dependent on the car (or rather I felt totally dependent on the car). When I discovered well-made bicycles, it became clear that I could make the vast majority of my trips that I used to make by car, by bike. I have observed this change happen to some people I know also.

¹⁷ Powerful people in politics, including the ex-scientific advisor to the government, Sir David King, tend to advocate high-tech adaptive pathways. It is clear that we no longer have the time, oil or money to perpetuate existing transport systems by relying blindly on unproven '50 year technologies.' Car dependence and fossil fuel dependence in general makes the UK vulnerable to shortages in supply. Car-friendly policy makes the population unprepared, physically and mentally, for the lifestyle changes that are needed if we are to adapt to in the long term to changes that will occur during the 21st Century.

¹⁸ Two events show that similar crises can be overcome: halving of Cuban oil imports and the UK's response to the Great Depression.

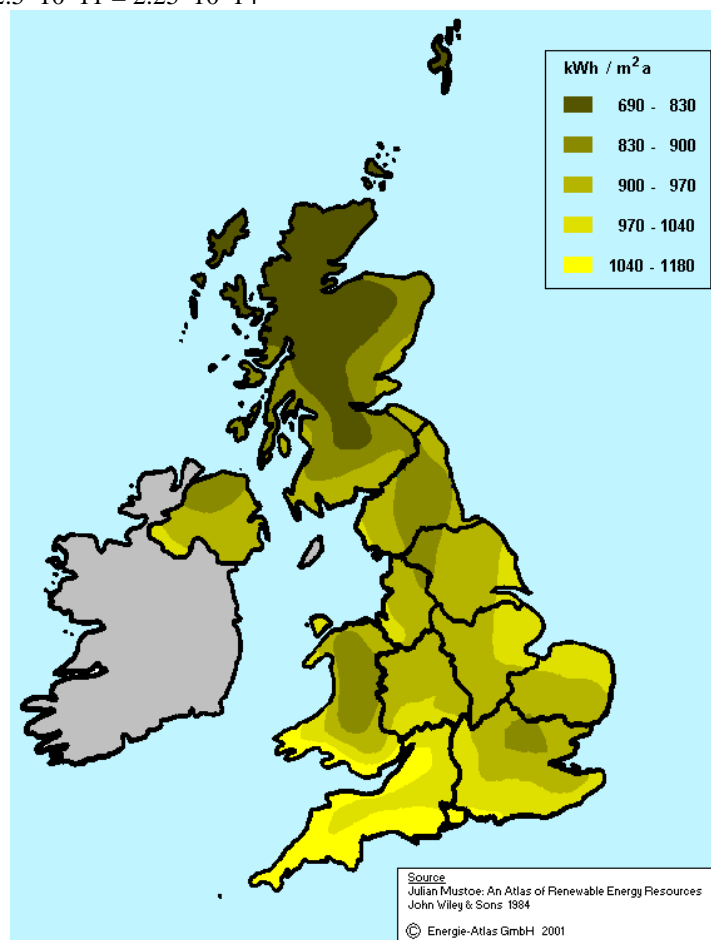
The example set by Cuba (if only in its approach to science) shows the situation facing the economy is not totally new. In Cuba, the state maintained a healthy population (political prisoners aside), despite a halving of oil imports caused by the break-up of the Soviet Union in 1989. It did so through simple technology, not least the import of thousands of bicycles from China. It also forced science to act in the public interest, to develop low-energy alternatives to its existing transport, agriculture and economic infrastructure. Can you imagine the UK surviving a 50% cut in oil imports?

The comparison with the Great Depression would be promoted by those who think that party politics is no longer appropriate, considering the threats we are facing. The reasoning goes that the UK needs to form a national government to plan for an uncertain future and stop the damaging Punch and Judie show of modern parliamentary politics. These plans would include a transition to a fully sustainable (zero carbon) transport system. The coalition that governed the UK between 1931 and 1940 to deal with the Great Depression provides a model of political strength needed to deal with such crises.

¹⁹ EIA data is used to show a peak in 2008: <http://www.theoil Drum.com/node/5047>

²⁰ The Chief Economist at the IEA, Fatih Birol describes how many projects are being scrapped due to the financial crisis (Birol, 2009).

²¹ The average amount of sunlight falling on the UK each year is 900kWh. The area of the UK is 2.5×10^{11} . $900 \times 2.5 \times 10^{11} = 2.25 \times 10^{14}$



(Thanks to www.helpsavetheclimate.com)