Wales in the Energy Crunch

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Wales in the Energy Crunch: Summary

Overview

There is increasing agreement that the peak of global conventional oil production will occur within the next 10-15 years, if not sooner. Crude oil comprises around a third of primary energy requirements, and almost 100% of energy use in transport.

The decreasing output of 'easy' oil will provoke a number of strong economic reactions. For example, there will be a rush to alternative fuel sources where technically feasible, including nuclear, gas, wind and biomass for electricity generation, and biofuels, gas and electrification for vehicles. Meanwhile, it is likely that development of oil from more difficult locations will intensify, as will that of 'unconventional oil' such as that strip mined from tar sands in Canada.

None of these alternative fuels and technologies will replace easy oil, or make any appreciable difference to the timing of the global peak in production. Each fuel faces significant geo-technical, environmental, political or economic barriers to increased production - sometimes all at once. Novel energy sources and new nuclear (or Severn tidal power) will not come on stream in large quantities before 2020 at the very earliest. Carbon capture and storage technologies, which may make the burning of coal possible without engendering catastrophic climate change, are likely even further away and requiring enormous investment.

The world then faces a very significant energy gap in liquid fuel availability in the upcoming decade, and probably beyond. The increasing concentration of remaining fossil fuels in a small number of regions with often problematic relationships with the West may see energy supply increasingly used as a political tool. At the same time the increasing demand and purchasing power of China (in particular) suggests that even where fossil fuels are brought to global markets, they will be extremely expensive.

In 2009-10 the UK will for the first time import more than half its gas; a proportion that will move inexorably upwards as North Sea reserves dwindle. Unfortunately, the former abundance of North Sea gas has meant the UK is ill placed to secure and store gas compared to its European partners: for example, whilst many European nations have developed bilateral long term contracts with supplier nations to buy gas, the UK typically purchases its gas on 'spot' markets. We are at the very end of the gas pipeline.

The response of the UK government to tighter and more volatile energy markets has been to call for their better operation. It also believes that should national (state-run) energy companies be replaced by multinationals, increased efficiencies would also drive increased supply. In the longer term, and linked to its climate commitments, the UK Government suggests that nuclear could produce a third or more of UK electricity, with the remainder renewably or 'clean' coal sourced

The prospect of an early peak in conventional oil and intermittence or expensiveness of gas disrupting this smooth medium term transition does not appear to form part of Government scenario planning.

Implications for Wales

Energy Generation

The substantial renewable energy potential of Wales remains largely unfulfilled. Wales produces 4% of its electricity from renewables (largely onshore wind) which is higher than England but significantly lower than Scotland (and indeed many other European countries). The installation of renewable capacity in Wales is progressing far more slowly than Assembly Government targets.

The commissioning of a large new LNG gas-fueled power station at Milford Haven and the continuation of generation at Aberthaw coal fired power station means that Wales will continue to be overwhelmingly fossil fuel dependent for its primary energy for at least the next decade - or for as long as such fuel is available and affordable. It is notable that the commissioning of the Milford Haven gas turbines, and the decommissioning of Wylfa, will increase CO2 emissions from power generation in Wales by at least 4.5 million tonnes per annum (around a 30% increase).

Energy Use and Competitiveness

Whilst the energy supply issues faced by Wales are mirrored elsewhere in the UK, there are substantially more vulnerabilities in Welsh industry. Wales is more manufacturing dependent than the UK as a whole, which means wealth generation is more energy intensive. Further, manufacturing in Wales is particularly energy intense, requiring over 50% more energy per unit of value added than the UK average. This means our manufacturing activities are more vulnerable to energy cost increases than other UK (and likely European) regions.

Some of Wales' key industrial players are in sectors which are likely to face significant restructuring in the face of energy scarcity and climate regulation. The implementation of EU regulations on carbon emissions may affect the competitiveness of each sector, whilst increased fuel costs and lower disposable income would particularly affect the prospects for Airbus.

In almost no case is a 'final' product made in Wales, let alone having a strong association with Wales, This means that there is little incentive for companies to continue to manufacture in Wales should cost competitiveness decline at a time when industries face significant reinvestment in production infrastructure.

Meanwhile, Wales' comparative lack of higher order innovative and R&D activities means it is unlikely that the region will gather much of the product and process innovation that will accompany volatile and increasing energy costs. Where Wales is innovative and has an international presence in the field of energy, organisations tend to be focussed more on social or environmental goals (such as those clustered around the Centre for Alternative Technology or Sundance Renewables). However, this activity at the edges of the economic mainstream, and in areas that possess little economic advantage in a traditional sense do show that people and organisations in Wales can make a difference, by thinking and acting 'outside the box'. Understanding and benefiting from these processes may be a key element in sustaining prosperity in future, even more challenging environments.

Travel and Transport

Employment opportunities that persist in the face of energy scarcity and climate regulation are a necessary but not sufficient condition for a long-term successful region. The people of that region also have to be able to get to and do those jobs; products must be brought to market and various services accessed by the people of Wales. This is a concern should fuel costs rise, with an often very limited set of substitutes for private car use.

In this context, Wales' dependence on the private car is a concern. A substantially higher proportion of commuting trips in Wales are by private car than in GB as a whole and with even more rural areas than Wales less car-dependent for commuting. This car dependence is not restricted to work trips: In 2005-6 Wales had the highest proportion of all household trips in GB that were by car. Wales also had the lowest proportion of children walking to school and the highest proportion driven to school of any UK region at this time

Some of these travel patterns are the result of geography and the dispersal of populations and services: for example, Wales has the poorest access of any region to hourly bus services close to home, and its children travel amongst the furthest to get to school. Whether these patterns are the result of socio-economic, cultural or purely geographic factors will be very important for policy development.

Proportionately less people in Wales work than in the UK, although that gap has narrowed over recent years. What has not narrowed is the gap in Wales-UK wage and income differentials, with Wales remaining at 12-13% below the UK. The combination of the highest car dependence, with amongst the lowest income (household and GVA) of the UK regions is concerning. This is not only with respect to access to work, but also services – especially for the one in six workless households in Wales. Transport and travel constitutes the largest single element of household expenditure, and the largest element within this is fuel costs. Relatively cheap motoring costs overall (despite increasing fuel costs) have encouraged the use of cars over relatively more expensive modes since 1990.

The implication of the data is that Wales is perhaps worse placed than any other region to absorb higher travel costs and/or climate taxation, especially those that impact more on private car use. With four-fifths of commuters travelling by car, increases in fuel costs have the effect of lowering the real wage. It is more expensive to travel to work, hence the differential between earned income and benefit payments decreases, encouraging more people, especially at the lower end of the income scale, to stay at home rather than work. The increasing real cost of bus and train travel over many years does not hold out much greater hope for non-car commuters.

In 2008 270,000 of Welsh households, were estimated to be in fuel poverty, a 12% increase on 2004 and showing that the Assembly aspiration to eliminate fuel poverty by 2018 is probably unobtainable in a regime of increasing energy prices. The 'double whammy' of increasing fuel prices for both home use and for travel means that many Welsh households face substantial falls in real welfare as fuel purchases comprise an increasing proportion of household spending - and with the number of these households proportionately higher in Wales than elsewhere in the UK.

Policy & Politics

The need to fundamentally change production processes and lifestyles, in an very short timeframe, yet with long and uncertain payback times on associated investments suggests that governments at all levels will play an increasingly important role in the economy. The lack of a critical mass in private sector innovation and lack of company autonomy in Wales suggests the government here will be even more important in the transition.

It is notable then that the National Assembly does not control energy policy for Wales, with centralised generation of over 50MW installed capacity remaining under the remit of Whitehall (and with this unlikely to change in the short term). However, Assembly Government policy (as opposed to aspiration) is currently very similar to that of the UK government, suggesting that even if the Assembly was to be awarded powers in this area, there is no guarantee an appropriately radical energy policy and implementation would follow.

With Wales subservient to London in many energy matters, the relationship between DECC in Whitehall and DESH and DET in Cardiff will be critical. For example there may be a tendency, despite DECC's UK-wide remit, to direct innovative low carbon technology and development to the South West of England rather than Wales, with the former identified as England's pathfinder low carbon region.

Public policy approaches to energy and climate are typified by an unwillingness to accept the existence of (and hence impose) substantial costs in the transition to an energy resilience. Here, the focus on short term 'regional competitiveness' precludes the possibility of imposing costs on existing stakeholders (such as high energy industry or users of private vehicles). This means Wales will travel no faster than other parts of the UK towards true energy resilience despite the need for greater urgency implied by our relative vulnerability.

Policy In Wales

The Assembly Government's broad policies on energy and carbon emissions are radical, brave and pointless. Planning Guidance support for renewables is far less strong an economic signal than support for a new 2000MWe gas fired station at Milford, or the planning permission for Ffos-y-Fran that enables Aberthaw to burn coal until 2018. What incentive is there to invest in smart grids; innovative dispersed generation; and politically difficult energy from waste plants or wind; when power is available at the flick of a switch from *currently* inexpensive gas and coal?

The problem here is that the continued dominance of fossil fuels in upcoming years may lock us even further into a path of dependency, meaning that should supplies be interrupted or become extremely expensive, the window for investment in truly large scale alternatives may have passed – in both financial and climate terms. In this scenario, those who suffer most are the poorest households in Wales and potentially, Wales itself as one of the poorest regions.

Energy policy in Wales needs to be far more complex and holistic if it is to be fit for purpose. Currently, there is very little discussion in energy 'route maps' and strategies regarding how different generation methods fit together in terms of complementarity, substitutability or cost. Without this, no assessment can be made of how likely take-up of renewables will be beyond purely regulated levels.

Wales has an aspiration, along with many other regions, to develop low carbon industries. A healthy dose of realism is necessary when considering this aspiration. There are very few policies extant in Wales which will encourage industry to 'green' more quickly than anywhere else in the UK – although our exposure to high energy costs may do the job for us sooner than we'd like. Assembly support is extended to companies irrespective of their energy profile or climate commitments. £28m spent supporting re-investment at Airbus cannot then be invested in low carbon, sustainable or energy resilient activities or products.

The identification of Aerospace and Automotives as favoured 'key' sectors in Assembly policy, and the continuing focus on these sectors (along with others that are currently high energy such as tourism and agri-food) sits uneasily within a green jobs strategy when Wales has access to none of the levers that might 'green' these businesses. Welsh aspirations for a low carbon future are wholly dependent on the adoption of appropriate technologies (where they even exist) by businesses in these sectors – and then their roll-out to Welsh operations. History suggests a measure of caution here.

Similar limitations exist in policies on travel and transport. Like other governments, the Assembly relies on carrots rather than sticks. The insistence of the Assembly that it will not toll any existing strategic trunk roads effectively signals that it is unwilling to impose costs on motorists beyond those imposed by the UK government. The prospect of modal shift occurring in Wales beyond any UK changes is therefore low.

Policies to improve walking, cycling and public transport infrastructures in Wales are welcome. However, policies which rely upon the incremental improvement of facilities, together with making citizens aware of low energy and CO2 options will have a limited impact, and this only in the medium term.

Unless the relative-cost and convenience issue is tackled extremely rapidly in favour of public transport, the majority of Welsh workers and residents will stop using their cars for day-to-day essentials only when car use becomes economically unfeasible. When this happens, public transport services will be unable to cope. Ramping up public transport provision by orders of magnitude whilst encouraging (or in some cases, such as in city centres, forcing) residents to use these modes is necessary if Wales is to function economically beyond peak oil. The appropriate policies are well known and proven in much of Europe - mandating priority bus and cycle lanes on arterial routes; high occupancy lanes; and car-free city centres; and with urban congestion charging and road pricing providing the income to enable investment in lower-carbon transport. Unfortunately all of this appears currently politically unacceptable.

Summary of the Problem

Fossil fuel energy traded on global markets is to become far scarcer in the medium term. In particular, availability of easily recoverable and easily refinable liquid fuels will decrease at a precipitate rate for geological reasons by the mid-2020s at the absolute latest, and with the significant possibility that the 'peak' of conventional oil may come far sooner (or in fact, already be passed). The behaviour of global energy markets in 2007 and 2008 suggest that once the absolute decline in 'easy' oil is priced in to markets, prices will respond quickly upwards, but with increasing volatility.

These price increases will affect not just oil, but its substitutes, such as liquid and piped natural gas. Meanwhile, the increasing concentration of the bulk of resources in a few countries brings into question how much fuel will actually reach global markets at all, with nationalistic concerns and behaviour already evident amongst resource rich nations. Moves by Chinese national companies to secure access to energy through joint ventures and trade-for-aid deals may also diminish globally traded supply.

All alternatives to liquid fossil fuels face significant problems in terms of access, be these technical, geographical, political, environmental or in many cases all four. There may be two trillion barrels of oil 'left', but much of it may as well be on the moon in terms of its usefulness for plugging short-to-medium term energy gaps.

North Sea oil and gas may have been more a curse than a blessing for the UK, leaving us short of energy storage and lacking long established commercial relationships with energy rich countries. Meanwhile, the prospect of peak oil disrupting the easy transition to a low carbon future is not even considered by the UK government. Despite our renewable potential, Wales appears more vulnerable than the UK as a whole to energy-cost induced disruption and poverty.

What Can and Should be Done?

The response of the UK government to upcoming energy issues is summarised by a belief in the power of open markets. Replacing inefficient state enterprises with efficient global companies in resource rich countries; encouraging further exploration; and freeing gas markets will be sufficient, in conjunction with squeezing our own North Sea gas, to ride the energy storm into a bright, low carbon future. If this analysis is correct, then Wales may have little to worry about. However, this optimistic reading has attracted sharp criticism; and not just from environmentalists The 2008 credit crunch and recession reveal the consequences of ignoring the potential for for systematic risks to go unnoticed within strategic industries.

The devolution settlement leaves limited room for manoeuvre in some respects, although even within the limited set of powers held by Cardiff, much could be done to prepare Wales more effectively for a higher energy cost world. We face a problem however. The framing of climate and energy security issues as 'win-win' in governments' dialogue with voters, together with continuing climate-change scepticism amongst some, means there is little incentive for politicians to suggest to the electorate that radical changes to their fundamental behaviours are needed. The spectre of appearing 'anti-business' appears to further restrict debate. This means that whilst actions taken in Wales appear worthwhile or even radical by UK standards they are doing nothing to prepare us for the changes we are likely to face, within the timescales we are likely to face them.

A number of policies, if implemented quickly, might serve to move Wales towards greater energy security and resilience. Each of the suggested policies has something in common: they would be generally unpopular. Whilst a debate with the Welsh people on the urgency of the peak-resource problem is obviously needed, it is perhaps less important than the creation of 'political space' within which AMs as a whole can show leadership. It is difficult to see how anything other than wide support within the Assembly (in the best case, fully cross-party) will allow this to happen.

The transition to energy resilience will involve significant investment. Whilst some of the actions undertaken will provide revenues for government (and perhaps even profits), this will be in the longer term, with investment spending required up front. The credit crunch and subsequent recession has left UK and hence Welsh public sector funding facing cuts in the near future. Again, in common with the rest of the UK, money will be hard to find, and investment will require the abandonment of other programmes. There are however a number of potential avenues which could provide funding for energy resilience interventions on a significant scale. These might include the redirection of monies from existing policies (such as flexible support for business); the utilisation of EU Convergence and transition funds; the issuing of 'green bonds' by the Assembly or LA partners; and, of course new taxes.

Conclusion

Economic and energy policy is increasingly shaped by the need to decarbonise production to respond to anthropogenic climate change. So far, however policies have failed to influence the structure of our economies sufficiently quickly to respond to the science. This is perhaps because climate change is a complex process, with long term and uncertain effects. The impossibility of 'seeing' these effects directly means that despite overwhelming scientific and government consensus regarding the causes and eventual severity of climate change, a public debate still continues as to its fundamental existence.

Further complexity arises because the worst of climate change effects are predicted to affect the global South and less developed nations. Radical climate change abatement is for Wales and the UK in part a moral action. As such it is open to debate and different attitudes based upon the subjective values of individuals. These facets have perhaps provided an incentive for governments and political parties of all types to avoid proposing the radical economic and public policies that the climate change science demands for fear of electoral punishment.

Peak oil, and the coming energy crisis, is *not* the same. Wales is amongst the most fossil fuel dependent regions of the UK, and with the UK having increasingly limited access to fossil fuel sources that are reliable and abundant. The impact of the global peak of oil production will be felt directly in Wales, by the latest within 10 years, perhaps more here than anywhere else in the UK, and with an economy and population less well prepared to deal than in other regions with substantially increasing and volatile energy costs.

There are two basic approaches that the current (and the next) Government in Wales can take to the energy crisis. Firstly, it could rely upon the UK government to fulfil its responsibility and plan for sharply decreased imported energy with a credible, costed and holistic energy strategy. In this case Wales would of course have to hope that UK-wide actions are sufficiently sophisticated to protect prosperity in Wales in terms of direct interventions (given our different industrial mix and population dispersal); that UK and European energy markets respond effectively to rapidly changing economic stimuli; and that public finances recover quickly enough from the dire position in 2009 to appropriately fund actions.

The other option is to assume the worst: that one or more links of this chain will break, and Wales will suffer substantial economic dislocation and increased poverty following an energy crunch. In this case, it is the responsibility of the National Assembly and Government to embark immediately upon a risk assessment exercise that identifies the key likely impacts of an energy crunch, and can suggest policies to minimize these impacts without the assumption that any current programme, sector, infrastructure or mindset will remain viable and appropriate.

Clearly embarking upon this route involves a difficult, complex and expensive journey, and probably the need to fundamentally reassess both the nature of party politics in Wales, and the quality of debate between Welsh politicians, civil society and people. It involves upsetting and inconveniencing many people. The alternative for Wales is to avoid serious debate and radical action and to follow the UK government in trusting markets to provide solutions. However, the fundamental geographic and character of Wales means that this failure in the duty of care will have the most severe consequences for our prosperity and wellbeing.

Policies for Preparedness?

A Sustainable Resource Map of Wales

There is currently no systematic understanding of the potential for the landscape in Wales to provide an increased output of energy which is fit to drive land use policy. A typology of land within Wales could be developed with ecological and topographical characteristics; elevation; wind profile; distance from grid points and current ownership and usage. The development of this 'blank sheet' classification system would indicate to what uses land in Wales could be put. Important here is the ground-up assessment of land potential, unconstrained by existing restrictions or conventions. The land use map developed above would provide intelligence to guide a plan of action to rapidly increase non-fossil fuel energy supply. Sites with prime technical potential could be quickly identified and the information on ownership and current usage used to identify those sites where development is immediately feasible.

Direct Intervention in Renewables

Identifying suitable sites is not adequate for action. Market, planning and perception barriers to the development of local non-fossil energy could be breached with the Government of Wales and its partners taking direct action to ensure security of energy supply. Starting with the prime spots in its own estate, and that of partner organisations (Unitary Authorities; Education; Forestry Commission) the Assembly could rapidly develop energy sources which are effectively in house – owned by, and with the output used by, public sector organisations. (and potentially with a measure of trading via the grid or directly).

Changing Travel Behaviours

In Wales as elsewhere, motorists have benefited from a relative cheapening of travel compared to other modes. Reversing this trend would require the Assembly to make motoring more expensive. Road pricing has the benefit of both reducing energy use and climate emissions, and potentially providing revenue with which other transport options can be improved. The 'inelastic' nature of demand for car travel means that those who can pay will continue to use their private vehicles even if prices increase significantly. Clearly, there is potential here for a nuanced policy to drive revenue increases which improve public transport for the very worst off.

A Single Focus Economic Policy

Assembly policy for economic development is the same as many other regions with alike situations: this approach has, unsurprisingly, done nothing to improve Wales' prosperity compared to other regions over many years. The opportunity exists, however, for the Assembly to concentrate its economic policy on one goal and one goal only – increasing regional energy resilience. Through this filter a very different set of industrial and labour market interventions will arise. Clearly this approach would involve the slaughter of many sacred cows, generic grants to business and general business support amongst them. Some companies in search of grant aid that is not linked to low-carbon production might not reinvest or even leave Wales. Companies might not choose to come to Wales in the absence of an unquestioningly positive attitude to business investment. These are not trivial concerns. However, the impact on actual regional economic performance is likely to be substantially less than that which would occur should Wales enter an energy recession at its current level of unpreparedness.

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1 The Energy Resilience of the Welsh Economy

resilience re·sil·ience (rĭ-zĭl'yəns) The ability to recover quickly from illness, change, or misfortune

American Heritage Dictionary of the English Language

'In terms of non-OPEC [countries outside the big oil producers' cartel], we are expecting that in three, four years' time the production of conventional oil will come to a plateau, and start to decline. In terms of the global picture, assuming that OPEC will invest in a timely manner, global conventional oil can still continue, but we still expect that it will come around 2020 to a plateau as well, which is, of course, not good news from a global-oil-supply point of view.'

International Energy Agency
Global Energy Outlook, 2008

1.1 Introduction

The above quote from the IEA represents at best, a radical increase in the 'cost of doing business' for global capitalism, and in the cost of day-to-day living for households in the developed world. At worst, the unavailability of cheap oil heralds a fundamental, potentially violent change in the way our societies and economies are ordered.

This should be a central concern for governments in all regions of the world and at all spatial scales. Firstly, there is a need to revisit policies for economic development (and even the concept of competitiveness) to assure their 'fitness' for an energy-constrained world. Secondly, the ability of residents to fulfil roles as economic actors in a time of extremely expensive mobility must be assessed. Thirdly, but outside the scope of this report, the viable delivery of public services such as health and education, currently spatially centralised, might be brought into question.

This report assesses the resilience of the economy in Wales to future energy shocks, both in terms of increased prices overall, and the volatility that is likely to go hand in hand with diminishing and more geographically concentrated fossil fuel energy supplies.

Also important in this debate is the ongoing process of climate change, both in terms of direct and indirect (to Wales) physical impacts, and in terms of regulation at different spatial scales that seeks to mitigate climate emissions, or adapt economies to irreversible climate change. Whilst this report does not address climate change per se, many of the critical issues for industry (and indeed society) are climate change related, and these are referred to as appropriate.

The first part of this report lays out the energy issues facing the world in the next decade, showing that even if one is extremely optimistic about new technologies and new fossil discoveries, we face substantial shortages of liquid fuel in this time. The main body of the report then examines how this may affect economic activity in Wales, and suggests that whilst our power generation capacity is potentially very significant, the region's current socio-economic profile makes it amongst the most vulnerable of UK regions (with the UK itself amongst the more vulnerable of Western European countries).

The third and final section of this report discusses some ways in which Wales could move to increase its energy resilience in the very short timescale needed.

1.2 The Issue

August 2009. Dr. Fatih Birol says in an interview with the Independent newspaper that 'we must leave oil before it leaves us'[1]. He reinforces his claim that current global energy use patterns are economically, socially and environmentally unsustainable, and repeated his prediction that global oil production would peak as early as 2020. Substantial energy price volatility, supply interruptions and electricity brown-outs will follow without early and radical investment in the re-engineering of global energy use patterns – an investment that shows little signs of happening.

There is nothing new about scientists predicting peak oil of course: ever since Dr. M. King Hubbert, a Shell Geologist, pointed out in the 1950s that any oil field must reach a 'peak' of annual production and then decline, he and other commentators moved to forecasting when such peaks may arrive for individual oil fields, countries and the world as a whole. Unusual about Dr. Birol's input was both who he is, and the detail of what he said.

Dr. Birol is the Chief Economist of the *International Energy Agency*, an intergovernmental organisation with 28 member states (mostly developed nations) which has a remit to examine issues of energy security and supply for its members. The IEA has long been considered a conservative commentator, and has been criticised for its assumption that OPEC (largely Saudi) production of crude could always increase to fill any non-OPEC gap between supply and demand[2]. its recent predictions that OPEC might have minimal spare capacity in the near future due to underinvestment (even before the credit crunch) is therefore startling.

The detail of Dr. Birol's peak oil forecast is also radical. Firstly, he suggests peak oil might happen by 2020 or earlier, rather than the 'beyond 2030' predictions of the IEA itself (and the assumptions of most governments). Secondly, the decline rates of oil fields following their peaks is revised upwards, following evidence from the North Sea, Mexico and elsewhere, where peaks have been followed by far faster declines in production (up to 8% per annum) than expected. The rapidity of these falls in production at established fields (even following engineering measures to extract as much as possible) will be a key determinant of oil availability – and hence, under current conditions, our basic security and prosperity.

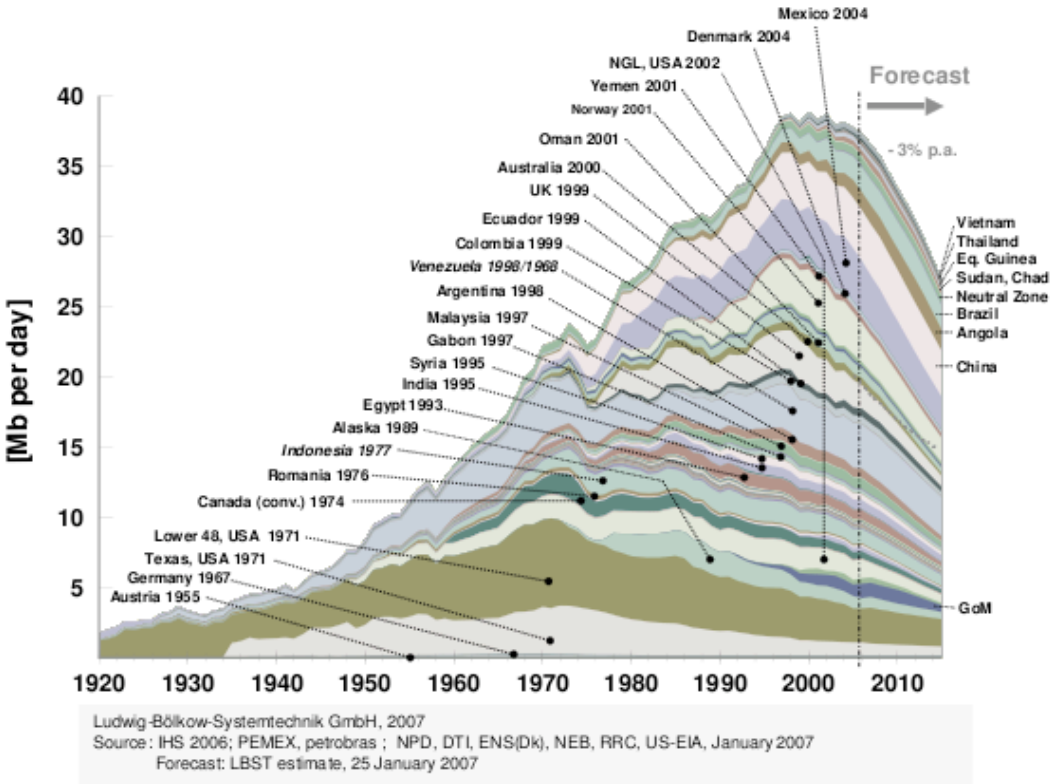


Figure 1 - Peak Oil Around the Globe

In the face of the above, it is perhaps surprising that a recent report commissioned by Gordon Brown on Energy Security for the UK does not even mention the global peak of oil and its implications for UK energy supply[3] (except tangentially – as is the case with the Wales Spatial Plan). Energy security for the UK (as we import more and more) is held to depend on 'better functioning' international oil markets and more bilateral agreements with gas producing nations (such as Russia one assumes) as we move to a low carbon economy.

The potential of unconventional sources of oil is also noted, as is the importance of new-nuclear to our post-carbon energy mix. This contrasts radically with the position on climate change, where the government has adopted an extremely challenging target on the cutting of greenhouse gas emissions by 2020: one which will have significant implications for our available responses to peak oil pressures.

Oil does, however, matter intensely for energy security – and, although outside the scope of this report, just as much for *food* security. Internationally, gas prices track those of oil, with the two fuels close substitutes for a number of uses. The concentration of supplies (and hence power) in energy will be greater as oil becomes scarce with an ever-increasing proportion of reserves in the Middle East, and with suppliers of gas, both liquefied and piped, already entering agreements which seek to replicate OPEC –and with gas reserves even more concentrated geographically[4]. Meanwhile, 'unconventional oil' in tar sands and shales, brings a multitude of technical and environmental problems as its production increases in scale.

With virtually no policy focus at UK-National level, it is unsurprising that there has been little attention to how energy scarcity might affect the prospects of individual regions within the UK. This report examines the Welsh economy to assess its likely 'resilience' to significant increases in the level and volatility of energy prices; how far will we be affected, the likely nature of the regional response and the implications of such uncertainty for regional prosperity. Comparisons are made with other UK regions as appropriate.

The National Assembly for Wales was directed to the importance of Peak Oil in a report published in Summer 2008 by its own research service[5]. There is little evidence that the Assembly Government recognises the severity and speed of potential impacts on Wales. Upcoming chapters examine how energy is (and might be) produced in Wales; assesses the likely responses of Welsh industry and workers to increased energy costs and also the role of policy at a Welsh and UK scale. First, however, the energy crunch is examined in more detail.

2 The Energy Crunch

> "Simply put, the era of easy access to energy is over. In part, this is because we are experiencing the convergence of geological difficulty with geopolitical instability... We are seeing the beginnings of a bidding war for Middle east supplies between East and West."
>
> *David J. O'Reilly*
> Chairman and CEO,
> Chevron Texaco Corporation 02/2005

> "I keep no secret from you that when there were some new finds, I told them, 'no, leave it in the ground, with grace from god, our children need it'."
>
> *King Abdullah of Saudi Arabia*
> April 2008

2.1 A Time of Systemic Change?

The introductory chapter makes it clear that future decades (indeed probably the *next* decade) will see reduced access to conventional 'easy' oil. The scale of this challenge, particularly if recent forecasts on post-peak oilfield depletion rates are correct, is difficult to over-estimate. Crude oil and its distillates (like kerosene and petrol) account for around a third of the world's primary energy supply but with this proportion approaching 100% in key sectors, like transportation. The supply of *mobile* energy, as well as its supply in 'gross' terms is a key concern for energy policy.

Moving away from oil as supplies diminish will create significant economic, social, environmental and, critically, political challenges whether the substitute fuels are fossil based or renewable. The potential for different fuels to fill the oil-gap is considered below. First, however, we speculate on what the market for oil might look like in 2020.

2.2 The Future of Oil

If we wish to speculate on what a future with more scarce oil resources might be like, the summer of 2008 provides an indication. Following a sustained period of global growth, significant price inflation occurred in a number of base industrial commodities (and indeed food) – and oil rose to $145 a barrel. Whilst the rise in most commodity prices could be traced to increased demand (notable from China), for oil the picture was slightly different. Actual levels of oil supply and demand in early 2008 were similar (about 86m barrels per day); however, oil is largely traded in futures markets, and concerns about political instability in the Middle East and Venezuela combined with significant unrest in Nigeria to induce worries about *future* levels of supply – hence pushing prices upwards[6].

At the time of this price increase there was debate regarding how far speculators had driven up the price of oil in order to make short-term profits. However, recent analysis by the US Commodity Futures Trading Commission and others[7,8] suggests such speculation had a marginal impact, if any at all. This is important. $145 oil was the result of fundamental demand and supply relationships, *not* short term speculation (which could be regulated to avoid a repeat). Moreover, this price spike occurred as a result of worries related to short term political instability rather than basic scarcity of supply.

Into the medium term, the IEA and others are predicting scarcity of oil due to underinvestment in both exploration and oil infrastructure. Levels of investment in both the fossil and renewable supply infrastructure have declined sharply since 2008 as the price of a barrel of oil dropped to $40and below (for example, the Canadian tar sands experienced a significant fall-off in investment and production).

The unwillingness (or inability; which is unclear) of Saudi Arabia to increase production as oil prices rose in Summer 2008 despite the entreaties of President Bush heralded a new era in global oil markets. Hitherto, Saudi supply had acted as a dampener on price movements, with the Saudis pumping more oil as prices rose (or to dissuade errant members of OPEC from excessive production) and less if prices dropped too far. It appears that the Kingdom will no longer fulfil this role for either political reasons (because it does not want to) or geological (because no more oil can easily be pumped in any given time period). This suggests that future oil markets will be significantly more volatile in future years[a].

[a] In November 2009 The Guardian reported an IEA whistleblower's claims that the IEA had systematically overstated reserve levels to avoid upsetting the USA and causing a global panic http://www.guardian.co.uk/environment/2009/nov/09/peak-oil-international-energy-agency

2.3 Gas

Projections of energy supply for the UK economy in the medium term suggest that gas may provide up to 75% of electricity generation – at least in advance of any new nuclear completion – as well, of course as providing much space heating and cooking fuel. Gas markets and prices are incredibly important then for the UK.

Markets for gas, particularly liquid gas, are far less well developed than for oil. Global markets (particularly in Europe) have been characterised by long term bilateral contracts, locking in suppliers and consuming countries over a period of many years and linked to oil prices.

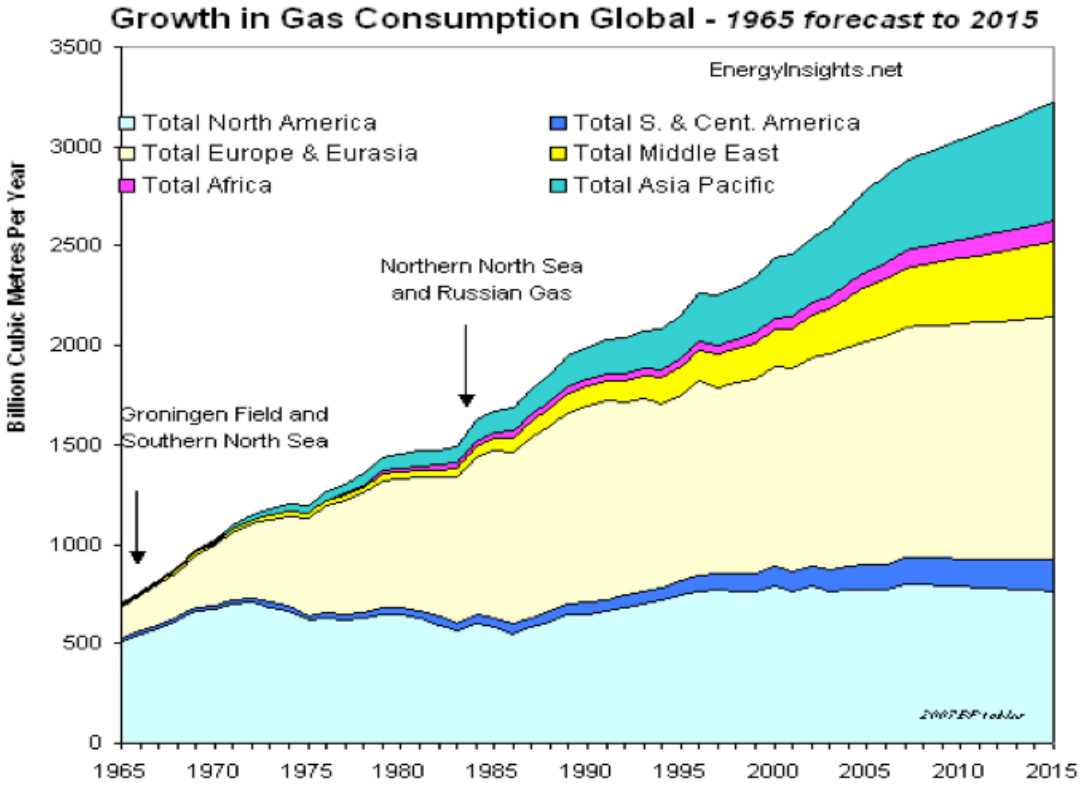


Figure 2 Global Gas Consumption

The UK, buoyed in the past by its own supply of North Sea gas has typically not participated in such contracts. In recent years, as North Sea output has decreased, the UK has bought gas on 'spot' markets that do not always operate efficiently, and with the UK effectively at the end of the gas pipe. A lack of storage capacity in the UK (less than one week's supply) means UK markets are subject to the full volatility of spot prices in Europe; increasingly so as our own supplies dwindle.

The peak of gas production is a subject of far greater uncertainty than of oil, because gas markets are not developed enough, and historic exploration extensive enough to fully assess reserves (gas field discoveries peaked in 1960). Peak gas occurred for the UK in about 2001 and for the Netherlands in 2007/8. There is some debate as to whether US gas production has peaked (excluding 'unconventional' gas; e.g. from shale). The vice president of Shell, in late 2008 raised the prospect of global peak gas in a similar timeframe to that of oil[9].

Perhaps of more importance than deciding on when the global peak of gas production might occur, is a focus on the concentration of supply. Not surprisingly given the relevant geology, this mirrors the distribution of oil with 40% of estimated reserves in the Middle East, but with Russia the single biggest player.

Table 2.1 World Natural Gas Reserves as of January 2009

	Tr ft³	*%*
World	**6,254**	**100.0**
Top 20 Countries	*5,674*	*90.7*
Russia	1,680	26.9
Iran	992	15.9
Qatar	892	14.3
Saudi Arabia	258	4.1
United States	238	3.8
United Arab Emirates	214	3.4
Nigeria	184	2.9
Venezuela	171	2.7
Algeria	159	2.5
Iraq	112	1.8
Indonesia	106	1.7
Turkmenistan	94	1.5
Kazakhstan	85	1.4
Malaysia	83	1.3
Norway	82	1.3
China	80	1
Uzbekistan	65	1
Kuwait	63	1
Egypt	59	0.9
Canada	58	0.9
Rest of World	581	9.3

Source: Oil and Gas Journal, Vol 106 no. 48

Recent developments have seen the creation of a gas 'troika' (Russia, Iran and Qatar), formed with the apparent intention of 'regularising' gas markets in a similar way to OPEC. Together, these three countries alone control 57% of known reserves. Their proportion of export potential is probably higher still: for example, recent Saudi developments in gas exploration are aimed far more at satisfying domestic than export demand.

The accessibility of this gas, either in piped or liquid form is a subject of some concern. Technically, pipelines must traverse long distances to markets across or under difficult terrain (politically and geographically) and with proposed pipelines to Europe subject to significant delay. Meanwhile, the transfer of liquid gas in ships is a relatively new development requiring huge infrastructure investment.

Politically, the situation is uncertain, with Russia already shown willing, through state-controlled suppliers, to use gas reserves as a tool of political bargaining and with many other potential exporters subject to political and social pressures that already limit their exports of oil (e.g. Nigeria, Iran, Venezuela).

The reality of the European situation is that even with significant investment on alternative energy sources such as nuclear or wind and the prioritisation of developing relationships with Norway, Saudi Arabia and Qatar, the UK will join the rest of Europe in an increasing dependence on Russian gas in the near term.

2.4 Coal

Coal is the most abundant hydrocarbon fuel, with an estimated 900 billion tonnes of proven reserves in 2006[10]. Coal deposits are more evenly spread than oil or gas, lessening potential supply issues, with the largest reserves found in the USA, Russia, Australia, China, India and South Africa. Coal production peaked in the UK in 1913.

It is worth here distinguishing the types of coal available, which range from high-energy anthracite (hard coal) though bituminous and sub-bituminous coal to soft, low energy lignite. The relative availability of these types is important for energy policy. For example, although the USA has the highest proven reserves of coal, it has (unsurprisingly) already used a higher proportion of its high energy anthracites and bituminous coal. This means that, year on year, the energy content of US coal production is already in decline: i.e. in energy terms the USA, with the largest global stated reserves passed peak coal in about 2000[11].

Carbon Capture and Storage infrastructure at the Sleipner field

Source: StatoilHydro

Clearly, coal substitutes for other fossil fuels in the production of electrical energy and for space heating, although is no longer used extensively in transportation. Coal can be converted to both gaseous and liquid form increasing the scope of use, albeit with some significant environmental concerns (particularly in the latter case).

As with natural gas, concerns other than geological availability are likely to drive its use in the UK (and Welsh) energy mix. Of the three major fossil fuels coal contains the most carbon and hence its combustion releases proportionally more of the greenhouse gas carbon dioxide: so much so that James Hansen, the head of the NASA Goddard Institute for Space Studies has called coal-fired power stations 'factories of death' and called for their immediate closure[12].

If the UK is to adhere to its own targets on reductions in CO2 emissions by 2020 and beyond, coal can only contribute an increasing (or even static) proportion of power generation in the advent of the quick and large-scale adoption of carbon capture and sequestration (CCS) technology, whereby the emissions of coal (or gas) fired power stations are captured and made safe.

CCS for power stations is as yet unproven on any industrial scale, and is limited to a number of experimental sites. At this early stage of development, CCS is estimated to cut the efficiency of power generation by 20-30% and involve substantial costs both at the 'tailpipe' and in terms of developing the transportation and storage infrastructure[13]. The volumes and weights are substantial: for example a 2007 MIT study estimated that if 60% of US coal-CO2 emissions (over a billion tonnes of CO2) were captured and liquidized for storage the resultant daily volumes would equal the daily consumption of oil at 20 million barrels – which must be safely stored for hundreds of years.

In comparison the Sleipner project in the North Sea is currently injecting a million tonnes of CO2 per annum into geological formations; equivalent to about 0.6% of UK power station emissions in 2006.

Given the economic uncertainties, necessary investment levels and technical difficulties inherent in CCS, it is safe to assume that it will have a limited impact prior to 2030 at the earliest, and hence climate considerations will substantially limit the use of coal in that period.

2.5 'Unconventional' and Remote Fossil Fuels

Reference has already been made in this report to the extraction of fuel (in liquid or gaseous form) from geological formations that have hitherto proved uneconomic or technically too difficult to consider when 'easy' oil was abundant. These include oil shales, tar sands and other strata as well as 'heavy' liquid oil, with the most advanced extraction underway in Alberta, Canada.

Global resources of unconventional oils are significant if ill understood. The potential (in terms of equivalent barrels) probably well exceeds the reserves of conventional oil. These reserves are concentrated in North America; sands and shales in Alberta and the Western USA and with heavy oil (much like conventional oil but slower flowing and more expensive to refine and transport) present in large quantities in the Orinoco basin of Venezuela and possible elsewhere in South America.

Added to these oils (which are chemically different to light, sweet, crude) are those which it has been uneconomic to extract in the past; for example under deep seawater and in remote areas such as the Arctic. A recent survey by the US Geological Survey estimated Arctic oil reserves as 90 billion barrels (enough for three-years worth of current demand) and gas fields which comprise perhaps a third of global reserves[14]. Meanwhile the discovery of the Papa-Terra field off the coast of Brazil promises up to 700 million barrels in reserves[15].

The usefulness of these fuels in providing a substitute for conventional reserves relates to a number of factors quite apart from the size of the reserves - illustrated by the fact that very few of them have yet been exploited. Due to their higher average cost of production, such reserves are only economically viable when the conventional oil price is high. As an illustration the cost of production per barrel of Canadian oil-sand crude is probably around US$40 per barrel for 2009 compared to well under $10 per barrel for Saudi oil. A major determinant of unconventional oil cost is the price of natural gas, with 1 million BTU of natural gas energy required to create a barrel of synthetic crude – itself equivalent to 5 million BTU[16].

Oil prices higher than this $40 are thus required for production to be economic (it is also notable that the Albertan government has instigated a very favourable tax regime for oil investment, with this aiding profitability). During early 2009, investment and production have slowed significantly in Canada following the recession and oil price slump. Other sources of unconventional oil will likely then be more expensive to exploit, although the future for average costs is difficult to predict (e.g. should technology improve).

Notwithstanding the economic issues, the rate of extraction is likely to limit the impact of unconventional oil on world supply. The most optimistic forecasts for Alberta suggest perhaps 6 million barrels per day may be delivered by 2035[17]. This is 7% of global daily demand and of the same order as current USA market needs (most Canadian oil is exported to the USA).

There are inherent technical and environmental issues in the production of unconventional oil. Industry proponents suggest greenhouse gas emissions associated with Canadian sands are only 20% higher than existing (North American) sources of crude, whilst environmental campaigners suggest the figure is 300-500% higher[18]. As uncertain is where the inputs for the production process will arise – vast quantities of heat and water are required.

Local environmental issues are also key to the development of this resource. The strip (effectively open-cast) mining of a large part of Alberta's wilderness, together with the compromising of groundwater and air quality has caused considerable disquiet on the part of Canada's citizens, and such issues are likely to make the extension of such activities into the USA extremely difficult.

The exploitation of heavy oils in Orinoco may hold better prospects in the medium term although the current nationalising tendencies of Pres. Hugo Chavez suggests it would be unwise to rely too much on supply from what has historically been a troubled region[19]. Similar issues may arise in the Arctic, which has already seen the beginnings of a national 'land grab' based upon the likelihood of hydrocarbon reserves.

In summary, unconventional and remote oils appear to hold some potential as bridging fuels should environmental and technical issues be resolved and should the price of oil remain high. However, most of these resources are subject to political and/or technical constraints and will likely not come to global markets in sufficient quantities to have a significant impact on either global energy markets' price levels or volatility in the near future and will certainly not be a simple substitute for 'easy' oil even in the long term.

2.6 New Nuclear

There is a clear wish on the part of the UK government that new build nuclear should fill much of the gap left by declining fossil fuelled energy production. Nuclear has the benefit of being an 'always on' power source[20] that emits insignificant levels of greenhouse gas during energy generation. Relatively low oil prices and concerns about safety and decommissioning have left nuclear unfavoured in recent decades in most countries but climate change and high oil prices have led to a re-evaluation here and elsewhere, with Ed Milliband in November 2009 announcing the fast-tracking of planning for new-nuclear at ten sites in England and Wales[21].

Nuclear energy is unlike fossil energy in that the fuel itself is a small part of overall cost, with these driven by substantial capital investment and significant (but very uncertain) decommissioning costs. Linked to specific sites, nuclear energy can only be internationally traded as electricity where facilities exist – for example along the interconnector between France and England – meaning that access is dependent not upon entering world markets but rather on home development of nuclear generation or bilateral contracts with nuclear near neighbours to access their surplus power when it available and needed (electricity is very difficult and costly to store in large quantities).

The difficulty with assessing the costs of new nuclear build has stymied development for many years. For example, the new Olkiluoto reactor in Finland is 50% over budget and three years late, with this being cited as either an example of why the inherent complexity of nuclear generation means its large scale roll out is unfeasible; or as the necessary 'learning curve' troubles associated with 'rediscovering' nuclear power development[22].

Nuclear energy is not, of course, renewable, relying upon the use of uranium (either mined or from secondary sources such as dismantled atomic warheads). The Nuclear Energy Agency estimates there is sufficient uranium for the next 100 years at *current* rates of consumption, but that this could be significantly extended with developments in reactor technology[23]. For example 'fast breeder' reactors can re-use uranium around 60 times but although this technology has been known for many decades it has never proved operable on a commercial basis (partially perhaps because relative abundance of uranium has meant the technology was uncompetitive; fast breeders are also considered a substantially worse proliferation risk than 'conventional' nuclear).

Despite the multitude of problems associated with new nuclear build, enthusiasm in both the UK and US suggests nuclear will provide an increasing proportion of electricity generation in many countries. The relatively[24] safe operation of nuclear sites in a number of countries, and the employment that has been associated with them, means that local opposition to their development may be muted or at least mixed[25].

It is very difficult to assess the whole-life costs of nuclear power compared to fossil fuel or renewably generated energy. This is partially because previous nuclear build has been subject to significant cost overrun (and capital costs are a very high percentage of overall costs) but also because decommissioning costs are so uncertain – and will not be payable for many decades. Costs per KWh of generation *whilst operational* are generally very competitive with fossil fuels and much cheaper than renewables at their current level of scale. This means that a market-driven approach to energy with a strong carbon price is likely to favour nuclear over 'clean' coal with the latter's relative energy inefficiencies and very high capital costs.

Estimates of decommissioning costs range from $300m per-plant to $1.5bn per reactor[26], but even these estimates rely upon the application of discount rates that may be inappropriate – for example, we cannot know the abilities of future generations to deal with nuclear waste; it may be far better or far worse than that available currently.

The UK's fleet of nuclear power stations is old, with only Sizewell B forecast to be still in operation beyond 2025[27]. A programme of building to replace the 24 currently operating reactors would then of course only hold the nuclear share at around 20% of grid energy rather than replacing any fossil fuelled plants that become uneconomic or illegal under resource depletion and climate change scenarios (assuming similar new power outputs).

In the best case, UK government policy would see a small number of new reactors online by 2018. However, the global dash to nuclear may have implications for the supply of nuclear investment expertise in the UK. India intends to have 20GW of installed nuclear capacity by 2020 – up from 4GW in 2007 and there is a similarly ambitious programme in China. Meanwhile, countries as varied as Indonesia, Vietnam and Turkey are intending to commission their first reactors in upcoming years[28]. Whilst some of these developments will use indigenous expertise, the prospect of a 'skills crunch' seriously hampering new nuclear build in the UK has to be seriously considered (especially with the future for the UK economy, and hence our power to attract internationally traded expertise, in some question relative to emerging economies.

In considering the position and scale of any new nuclear build, it is worth also remembering that if liquid fuels become scarce, electricity will likely be required to fill the energy-for-transportation gap, either by charging electric vehicles or splitting water to produce hydrogen for vehicle fuel cells. This alone might *double* the required size of the UK electricity grid with ramifications for how many reactors will be required.

David MacKay has estimated that a market-based approach to energy generation which favoured nuclear over fossil fuels and renewables, and in which the majority of electrical power (including for transportation) was this nuclear-supplied would require 110GW of nuclear capacity – ten times our existing fleet, and equating to a pair of reactors every 30 miles of coastline around the UK[29].

2.7 Renewables

There are a number ways in which energy and heat can be generated from the environment in ways which do not diminish the future ability of that source to generate power. Current commercial technologies include, amongst others, wind turbines (on shore, off shore), tidal turbines (in rivers and estuaries) and solar power (solar water heating, photovoltaic electricity generation).

The relative abundance of fossil fuels (and many would argue the unwillingness to 'price in' their negative environmental impacts) has meant that renewable generation has been generally unable to compete commercially[30]. Renewables rely on the use of the sun's current energy harvest (either directly or indirectly) whereas fossil fuels draw upon millions of years' worth of stored sunlight energy: the former is typically diffuse and low density, requiring harvesting at geographically large scales, whereas the latter is incredibly energy dense, meaning useful power can be gained by burning fuels at a single site.

The lack of price competitiveness of renewables with fossil fuels or nuclear means technology is in many cases still relatively underdeveloped with R&D budgets tiny compared to those of other generation types (or in transportation). This means that, optimistically, cost per KWh might fall as technologies improve and economies of scale arise as implementation spreads or, pessimistically, that barriers to development may become obvious as the use of renewables grows.

Whilst the UK has limited further potential for large-scale hydro-electric development (on lakes and rivers) it is relatively well resourced in terms of wind, wave and tidal power compared to the rest of Europe[31]. These resources have not however, by and large, been translated into actual generation, with the UK producing only around 1.3% of its power from renewables in 2005 – the lowest in the EU bar Malta and Luxembourg[32].

This lack of development illustrates a central problem with renewables: their installation on a scale which might conceivably replace the bulk of fossil fuels requires substantial changes to the physical environment; whether this is in terms of altering the 'visual amenity' of hillsides or having massive implications for the ecosystems of our largest estuaries and the rivers that feed them.

The variability (over time) and geographic dispersal of most renewables will require substantial investment in electricity infrastructure (and potentially in demand management) to adapt to their widespread use. This might involve the construction of 'smart' grids, large-scale storage capacity (hydro or batteries) and many new grid termini (indeed, in the case of levering Saharan sunlight power for Europe an entirely new intercontinental high voltage DC transmission system).

Whilst fossil fuels are still available, and with our energy infrastructure optimised around their particular characteristics, markets alone will not invest in the wholesale renewal of the generation infrastructure: renewables must offer not only cheaper power per KWh, but sufficiently cheaper to repay this significant investment. Here, the nascent state of much renewables technology gives little clue as to how increasing installation might drive down costs through economies of scale to improve returns.

So far, governments' interventions in favour of renewables (including the European Trading System for carbon) have had limited success in triggering such a shift. Whether this investment will be technically or financially viable whenever fossil fuels do become unavailable or uneconomic is an interesting debate.

2.8 Summary

The preceding sections of this report have hopefully illustrated that a fundamental shift in the quantity and character of the energy available to the world is imminent. Moreover, the market and policy responses to this shift have so far been inadequate to insure against widespread disruption to economic activity – and indeed potentially to access to commodities and services we consider fundamental; food supply chains for example are wholly oil- or fossil-fuel dependent; from the milking of the cow to the delivery of milk to the supermarket.

The geological reserves of a given fuel will not be the only driving factor determining its price and availability on global markets. Increasing scarcity will drive commercial and nationalistic responses to retain or attain remaining resources long before 'the oil runs out'. In the best case scenario, fossil fuels will continue to come to global markets in large quantities, albeit with these quantities decreasing and subject to intermittency as 'easy' options recede – and with prices commensurately higher and more volatile.

In this scenario, the winners will be the energy companies and resource-rich countries (increasingly fewer in number) who can drive prices higher and realise ever more substantial profits. The lesser losers may be those countries able to purchase fuels at high prices – which may *not* be those traditionally thought of as 'rich' countries. These have already in many cases substantial balance of payments deficits, and with these set to worsen as their energy import needs grow. These countries may be the biggest losers.

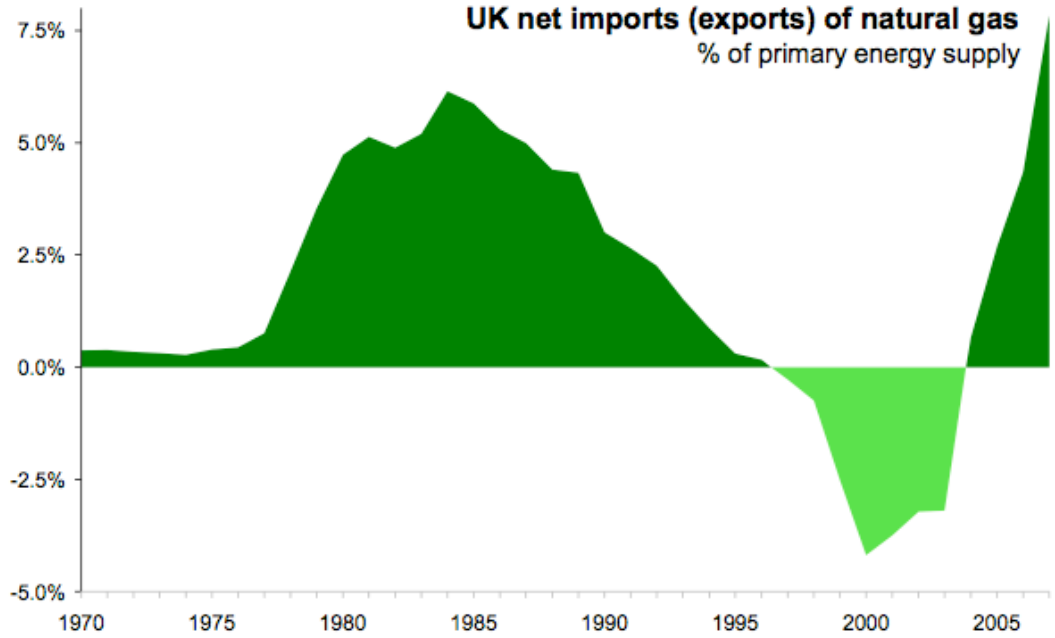


Figure 3 Increasing Dependence on Gas Imports

Source: House of Commons Library Research Briefings Snsg-04046

A worst-case scenario might see the dominance of national-commercial organisations and considerations work to diminish the role of global energy markets *per se* – meaning far less of the available resource is actually freely traded. The potential implications of this outcome are already clear; for example in Russian Gazprom's cut in supplies to Ukrainian pipelines (and hence European customers) with gas following a commercial (some would say also political) dispute with that country in January 2009 following earlier disagreements[33].

At the moment, and due to its relative under-development commercially, gas is available in liquid form to the UK from Qatar (indeed is at the moment in glut). However the involvement of Qatar in the 'gas troika' and indeed the implications of a very concentrated supply in general need to be carefully considered.

It is uncertain whether unconventional oil will reach global markets in sufficient quantities; concentrated in America and with substantial demand to fulfil on that hemisphere, it may be that available resource is subject to long term bilateral contracts (as in the case of gas) rather than subject to short term global trading.

Any discussion of the future for global energy markets is incomplete without reference to the new customers for fossil fuel energy: India and, particularly, China. The latter, through its sovereign funds and commercial intermediaries has embarked upon an assertive drive to ensure access to a variety of energy supplies. Close to home, investments have included the Central Asia-China gas pipeline and a mooted (albeit recently postponed) Russia-China gas pipeline.

Further afield, China has been increasing its presence in Africa, which although holding a small proportion of world oil reserves is considered to have potentially larger undiscovered resources. Activity in Africa involved integrated trade-aid deals with a number of countries (notably Sudan and Angola) and investment in production infrastructure and offshore fields[34]. China currently imports a third of its oil from Africa

Whilst Western companies remain by far the larger investors in Africa, it should be remembered that their investments are largely 'nationally neutral' – i.e. driven by the profit motive and with objectives realised by bringing oil to markets. It is unclear how far this would be true of Chinese companies where the government retains in many cases a controlling interest (either legally or in practice).

Following the financial crisis of 2008, Chinese (and indeed Middle-Eastern) investments have speeded (to take advantage of lower commodity and other costs), and the crisis appears to have speeded the shift of economic power eastwards.

There are very few certainties in this dynamic energy picture except the certainty of change. There appears to be little prospect of energy, whether in primary or electric form remaining at a price comparable to that of history. The very availability of some important fuels is not guaranteed, even in the medium term. Following sections discuss the implications of these deep structural changes in the energy landscape for Wales.

3 The Future of Power Generation in Wales

> 'Emissions from electricity generation in Wales have increased by 24.4% compared with a fall of 9.9% in UK emissions over 1990 to 2006'
>
> *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2006*
> AEA/DEFRA, September 2008

3.1 Power Generation in Wales

Currently Wales is a net exporter of electricity; in 2006 the region exported 11% of its generated power to England[35]. Whilst data is not available on power station basis, it is reasonable to assume that this is due to the output of Wylfa nuclear power station (either directly or after storage) and Connah's Quay gas turbine finding use in the conurbations of north west England,.

Wales' electricity export performance is in decline, down from almost 15% in 2004. This was very likely driven by unplanned outages that cut the output of Wylfa in 2005 and 2006[b]. These short term trends point towards what *may* be more systematic changes in the relationship between Wales and England in the longer term.

Wales displays some differences with the rest of the UK when in comes to generating electricity. We are rather less dependent on coal compared to England and Scotland, and commensurately more dependent on gas. Meanwhile, our nuclear proportion is slightly higher than that of the UK. These figures exclude pumped storage, as this mechanism (pumping water up to a higher elevation at times of low demand and generating power from this water when demand is high), although technically generation, is a net consumer of electricity, albeit economically profitable.

Wales outperforms England (& NI) in the generation of power from wind wave and solar (largely wind). However, Scotland is substantially ahead of Wales in the proportion of renewable generation. When one adds the (long established) hydro-power stations on Scottish lochs and rivers to the wind generation, Scotland can claim well over 10% of its power as renewable.

[b] It is worth noting that between 2005 and 2006 unplanned outages cut Scotland's nuclear generation by 25% leading to a substantial increase in the use of coal in that year.

Table 3.1 Power Generation by Type 2006: Major Producers plus Wind, Wave & Solar

	UK	*Scotland*	*Wales*	*England & NI*
Coal	40.4%	37.7%	29.6%	42.1%
Oil	0.8%	1.9%	0.0%	0.7%
Gas	35.0%	18.0%	43.7%	36.8%
Nuclear	20.8%	30.5%	23.1%	19.0%
Thermal Renewables	0.8%	0.0%	0.1%	1.0%
Hydro natural flow	1.0%	7.5%	0.7%	0.0%
Wind, wave and solar	1.2%	4.4%	2.9%	0.5%
Total	100.0%	100.0%	100.0%	100.0%

Note: will not equal total generation due to exclusion of pumped storage & other renewables
Source: BERR (ibid)

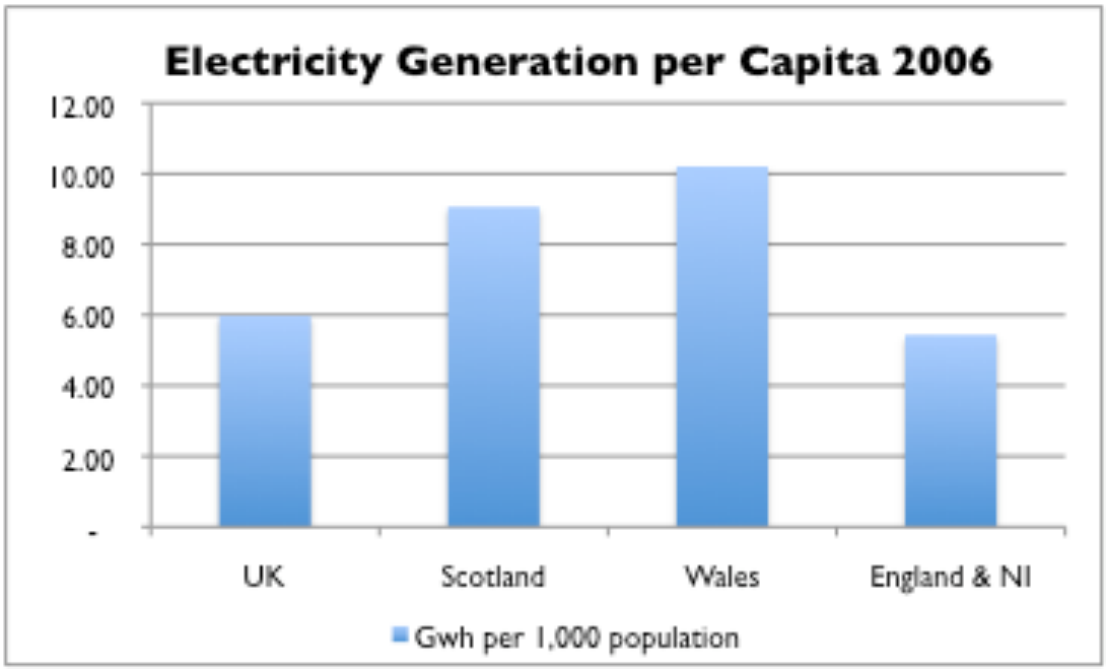


Figure 4 Electricity Generation per Capita

Source: DBERR & Registrar Generals' Mid Year Estimates

By comparing the level of power generation in 2006 with the population of each country we see that Wales produces in 2006 more electricity per person than any other part of the UK. This is particularly notable when one considers that Scottish generation overall was not dented by the nuclear outages of 2006 (in fact, overall electricity generation increased in this period as coal fired plants more than took up the slack.

This relatively intense generation of electricity per capita (almost twice as high as England), combined with an export ratio of only around 11% suggests something else is happening to the generated power (even allowing for the pumped storage facilities at Dinorwig and Ffestiniog). That subject is returned to in future chapters.

3.2 The Power Generation Fleet

The above discussion suggests that Wales is generally well placed in terms of electricity generating capacity. However, as in the rest of the UK, some significant changes are imminent with regard to the scale and nature of electricity generation in the region.

Most pressing is the closure of Wylfa nuclear reactor. Despite an extension, this is now set to follow Trawsfynedd into closure in 2010, and with it around a quarter of Wales' existing generation capacity. The lack of an imminent replacement has already seen the closure of the Anglesey Aluminium smelting plant, which relies heavily on Wylfa's inexpensive electricity for its competitiveness.

Aberthaw coal fired power station meanwhile continues to operate. This a very large facility: at almost 1500MW of installed capacity, it is 50% larger than Wylfa and only rivalled by the gas turbine at Connah's Quay. Aberthaw gained a stay of execution with the addition of desulphurization equipment in 2005, and a similar investment has been made at the smaller Uskmouth coal fired power station. The granting of the license to opencast coal at Ffos-y-fran, together with the co-burning of biomass at these plants has probably extended the life of Wales' coal fired stations for another decade[36]

Other fossil fuel plants – which in Wales means gas – are relatively new; Connah's Quay and Deeside are a little over ten years old and the 500MW turbine at Baglan half that. In 2009 the UK government gave permission for a new 2000MW gas fired combined cycle power plant at Milford Haven, to burn LNG imported from Qatar. In the short term this would more than replace the capacity lost at Wylfa, albeit at the other end of Wales.

Just over 4% of Wales' net electrical output was supplied by renewable sources in 2006, an increase of 1 percentage point on 2005[c]. Thermal renewables (power from biomass) is a small proportion of this total: we are generally talking here of generation from wind and hydro.

[c] Renewables comprised a higher proportion of installed capacity as their levels of variability are generally higher than fossil fuels. The ratio of installed capacity to power generation is called the load factor.

North Hoyle was the UK's first (and is Wales' only) major offshore wind farm. Its installed capacity is 60MW (30 x 2MW turbines). Assuming a load factor of 30%, this equates to 20MW-equivalent of likely generation.

According to latest figures[37], Wales has around 300MW of installed onshore wind capacity, and 150MW of hydro. This renewable capacity of 550MW (including landfill gas and biomass) equates in total to the relatively small gas turbine at Baglan, although the latter would typically produce more electricity given wind power's lower load factor.

3.3 The Future Generation Mix

Immediate plans in Wales for new centralised generation capacity are limited to the 2000MW station at Milford. Further into the future, there have been suggestions for new capacity on the sites of (or close to) existing power stations to take advantage of existing grid infrastructure. Specifically, Wylfa on Anglesey is one of eleven potential sites nominated by energy companies and the Nuclear Decommissioning Authority as appropriate from a technical standpoint[d] and with RWE has been granted permission for a new grid connection at the site.

If in the first wave of development (and if new nuclear happens quickly in the UK) a new reactor could be operational at Wylfa by 2025. The first wave of new nuclear will unlikely extend to the 11 identified sites meaning Wylfa's inclusion is uncertain; it was placed eighth most appropriate in an earlier siting study, with Hinkley and Sizewell most favoured, although this was before the application for the new grid connection had been granted[38].

The enthusiastic support of local authority on Wylfa must be tempered with the view of the Assembly Government (in late 2007) that upcoming investments in fossil fuel and renewables in Wales made new nuclear build here 'unnecessary' in the next 10-15 years[e]. Although the UK government controls energy policy in respect of developments over 50MW of installed capacity (and planning control for such sites), the lukewarm (at best) position of the Assembly may lead energy companies and the UK government to conclude that initial investment should take place in a less politically complex region.

[d] All sites have existing reactors; an earlier suggestion that Aberthaw might be included seemingly proving false

[e] This cabinet paper also assumed the widespread introduction of carbon capture and storage in this period which raises both technical and economic questions.

Apart from new gas-fired plants, the Assembly government envisages a substantial increase in renewables as filling the energy gap. There is a target that 4 Terawatt hours of power (4,000 GWh) should be produced from wind sources by 2010. This would equate to over 10% of total generation in Wales. As at 2006, Wales produced around 1,000 GWh of power from wind and wave, meaning a four fold increase in generation in four years would be required to attain this target.

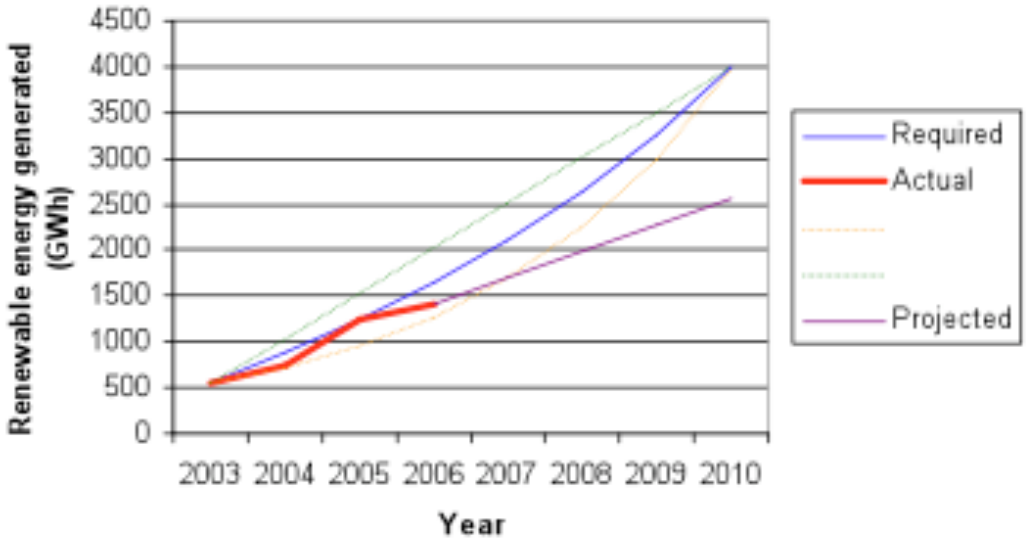


Figure 5 Renewable Energy Generation in Wales

Source: DBERR

Data on installed renewable capacity to the end of 2007, and the protracted nature of the land use planning system, suggest this target is unlikely to be met

The Assembly Government's renewable energy roadmap highlights the importance of biomass (including from waste) with the Minister estimating up to 7,000 GWh (and 3,000 GWh of heat) could come from this source[39] although resistance to the development of a 350 MW plant in Port Talbot burning wood suggests that the 'selling' of widespread waste incineration to local communities will require careful consideration.

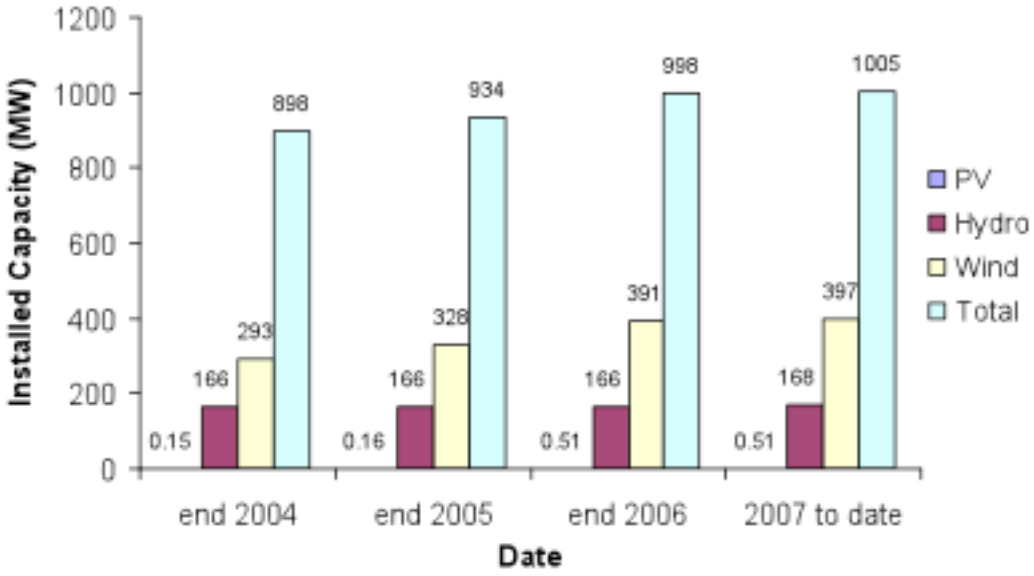
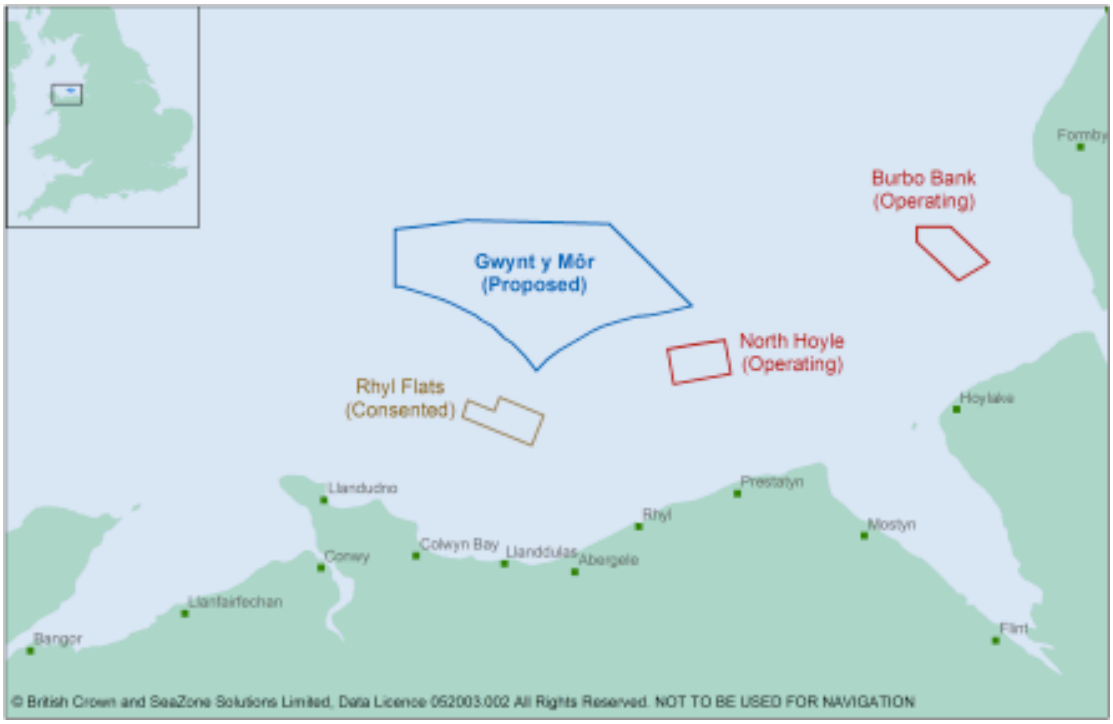


Figure 6 Installed Renewable Capacity in Wales

Source: Scottish Power / Western Power Distribution

Not without controversy are large offshore wind farms. Joining North Hoyle off the coast of North Wales, the Gwynt-y-Mor windfarm has been granted planning permission. This substantial 750MW development by RWE-npower might be operational as early as 2014[40].



The Renewable Energy routemap for Wales, launched in 2005, suggests that Wales could supply all its electrical energy (33,000 GWh) from renewables by 2025. Around half of this total would come from marine sources – wind, wave and tidal stream – thus requiring the rapid development of technologies which are in relative infancy.

It is however unclear how this large scale re-engineering will be implemented. With limited power over energy issues, the Assembly must rely upon liaison and persuasion with relevant authorities and companies, together with UK developments (such as Severn tidal stream developments) and encouraging developments through the land use planning system. The presumed hope is that the market to do the rest.

With a less than radical phase 2 of the European carbon trading system on the table, relying upon a high carbon price to significantly change the relative price of renewable and fossil fuels may be unwise. With Wales currently self reliant in electricity generation, and with the approved new gas plant at Milford Haven having five times the 'nameplate' capacity and probably ten times the power generation potential) of Wales' entire current wind turbines, the most likely outcome must be on a relative increase in the dominance of gas as the primary generation method in Wales in the near (and perhaps medium) term despite Assembly policy.

3.4 Summary: Issues for Power Generation in Wales

Wales does not have a problem with electricity generating capacity in terms of overall scale, with a level of power generation relatively far higher than England and equivalent to Scotland. At issue may be the geographical dispersion of that capacity and, critically, the electricity infrastructure that will be needed to move power generated in a more dispersed, renewable-heavy mix to where it is needed.

If Assembly aspirations are met, Wales will be energy secure by 2025, and move well ahead of England in this respect. However, and in common with the UK situation, there is so far little prospect of policy translating into on-the-ground investment at the scale required. Even the largest renewable plants so far approved such as at Port Talbot are small compared to existing and proposed fossil fuel developments, with micro generation nowhere near filling this gap.

In the absence of a strong carbon price or UK government action to further force renewable generation over and above EU moves, Wales's aspirations will be stymied by the relative expense of most renewables compared to fossil fuels. The potential for new nuclear generation in North Wales also makes it difficult to assess the investment conditions for developments that add to those such as Gwynt-y-Mor in the longer term.

There is an issue additional to generation capacity however. Currently Wales imports around 80% of its fuel for generation from outside the region, with coal, largely from Ffos-y-Fran and other opencast, and renewable wind making up most of the remainder. In previous decades, fuel imports have come from the rest of the UK but as Figure 3 shows, this is changing quickly. Security of fuel supply is thus of critical importance.

The South Hook and Dragon LNG terminals at Milford Haven have the capacity to supply around a third of the UK's *current* gas needs from fields primarily in Qatar, but including Algeria, Egypt and elsewhere (although as gas consumption continues to increase this proportion will drop, meaning reliance on Eurasian gas will increase in Wales as in the UK[f]). The 67% ownership of South Hook terminal by Qatar petroleum should ensure that Wales and the UK remain a key entry point to Europe for Qatari LNG as that country's exports increase, albeit the price implications of Qatars' involvement in the 'gas troika' are yet too early to judge, especially at a time of recession.

[f] The Milford developments will not of course supply gas to mid or North Wales

Some commentators have noted that Asian spot prices for gas before the recession were double those in Europe, and suggested that the 17m tonnes per annum that the terminals can process may never arrive, with the gas diverted to more lucrative markets[41]. Diversion of gas according to changing spot prices is commonplace – for example of 48 arrivals scheduled at the Louisiana LNG terminal in late 2007, only 11 actually arrived, with the others diverted to more profitable destinations.

The structure of the contracts under which LNG is brought ashore at Milford means terminal owners are paid per available dock, rather than per ship-arrival – meaning there is less of an incentive to ensure LNG deliveries[42]. Bidding wars for LNG cargoes have, of course abated following the global recession but there is nothing to suggest they will not return with recovery. Future economic planning should assume substantial increases in the price of gas as a probability, and interruptions to supply from one of our few primary suppliers as a significant possibility.

3.5 Climate Emissions from Power Generation

Milford Haven has the distinction of being currently (or at least on latest figures) only the third largest emitter of industrial greenhouse gases in Wales; the Total and Chevron refineries together emit around 3.5 million tonnes of CO2e, some way behind Aberthaw and Corus Port Talbot. The completion of the 2000MW gas fired station will likely add between 4.5 and 5 million tonnes of CO2 to annual emissions, pushing the Haven into first place overall[43].

The completion and use of the Pembrokeshire power station will add around 30% to electricity generation carbon emissions in Wales (effectively replacing the notionally zero carbon source of Wylfa). With Aberthaw likely to be open until at least 2018, it is as well that large scale power generation is not part of the Assembly's devolved remit. The aspiration to cut emissions by 3% per annum from 2011 in devolved areas would otherwise appear nigh impossible.

4 Welsh Industry: Energy Intensity and Competitiveness

> "That is what sustainability means to us. Current market conditions are exciting, but the challenge to increase volumes, quality and revenue is more intense, coupled with our challenges in corporate social responsibility.
>
> *Uday Chaturvedi,*
> MD, Corus Strip Products UK

4.1 Introduction

The energy supply issues to be faced by Wales in the next 5-15 years are certainly substantial - and possibly extremely painful - but they are, by and large, similar in nature and scale to those to be faced by the UK and Europe more generally. Indeed, with access to LNG, and significant potential in wind, wave and pumped storage Wales might be considered rather better off than some other UK regions.

This is not, however true of the demand side. For a number of reasons related to geography and industrial history Wales is more vulnerable to systemic change in global energy access (and consequent change in economic structures) than most other UK and European regions. The consequence of this vulnerability may be an even further relative decline in prosperity and social welfare.

The growth of economic disparity in the UK will have far more troubling implications in a fuel-poor world than it does currently; particularly given the possibly lower levels of support that the national government will be able to provide to lagging regions (and lower income groups) following the noteworthy deterioration in the UK's financial position consequent on the 2008 credit crunch and recession.

Following sections then examine the implications of fuel scarcity for economic life in Wales. We begin with an assessment of how Welsh industry is placed to cope with a rapidly changing energy environment.

4.2 The Energy Intensity of Industry in Wales

An extreme example of the potential for energy issues to impact upon economic development in Wales has been offered in 2009 with the closure of Anglesey Aluminium. This plant was extremely energy-intense, consuming around 8% of Wales' entire supply of generated electricity. A long term contract with Wylfa nuclear power station guaranteeing lower than market prices for electricity could not be renewed following the decommissioning of that plant (and indeed EU rules that forbid such subsidies to metals industries). A grant offer of £50m from the Assembly & UK government was not enough to persuade the plant's owners to continue operations in the face of short term drops in aluminium prices and long-term trends in energy prices[44].

The loss of 400 jobs, plus probably an equal number in the supply chain, is a significant blow for an island that already has economic problems, and is losing its nuclear power station (although decommissioning works will continue there for some time, hopefully providing continued employment at some level). Anglesey aluminium is also regionally important, with a turnover of £200m and a wage bill of £20m it was one of Wales' most important industrial companies.

Whilst Anglesey Aluminium was the most extreme case in Wales of an energy-vulnerable company, the general economic structure of Wales is more energy intensive than the UK average. The REWARD project (Regional and Welsh Appraisal of Resource Productivity and Development) sponsored by the Assembly, the Environment Agency and a number of regional development agencies estimated that Wales consumed 7% of all the carbon fuel used by the UK – proportion well in excess of its population share of around 5%.

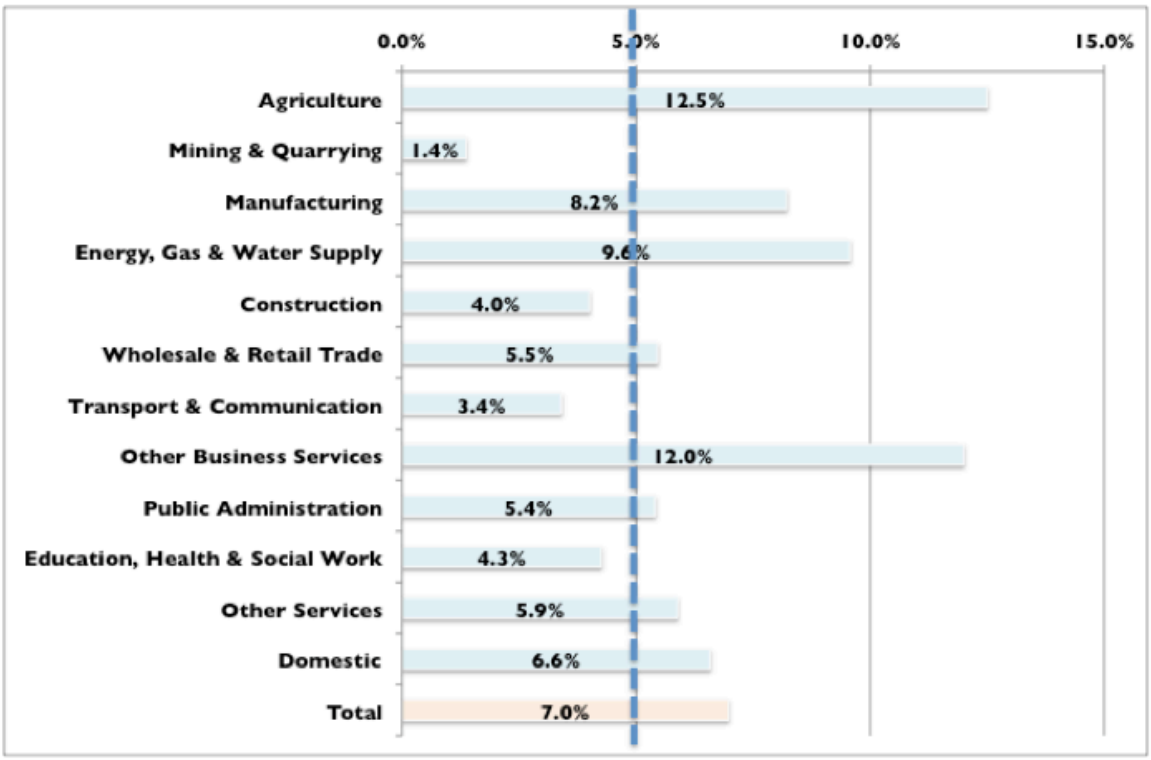


Figure 7 Direct Use of Carbon Fuels in Wales: Percent of UK (2003)

Source: REWARD project; http://www.wwflearning.org.uk/scpnet/tools/reeio/

Figure 7 indicates that this disproportionate consumption was a consequence in part on a relative concentration in carbon-energy generation, manufacturing and agriculture – all heavy users of energy[g]. Other sectors, such as mining and quarrying and (industrial) transport consumed a lower than expected proportion, probably due to their relative scale in Wales. Worryingly, the domestic (household) sector in Wales was also estimated to consume far more fossil fuel energy than its population share would suggest.

We have already seen that Wales has more electricity generating capacity than the UK average, with this, and our concentration in water supply, driving the high figure in energy, gas and water, proportionately double that of the UK. It is worth noting here that no more people are employed in this sector than the national average, as a result, possibly of a combination of relatively high capital intensity, the subcontracting of maintenance services and a low level of local ownership (excepting water)[45].

[g] although business services performed very poorly, the overall emissions of this sector are low.

To summarise, manufacturing in Wales in 2003 created £7.5m of value added for every GWh for energy used directly from carbon sources[h], whereas for the UK the figure was £12.6bn. Put another way, whilst the UK requires 80 GWh of carbon energy to create £1bn of manufacturing, Wales requires 133 GWh.

The story in manufacturing is complex. Firstly, we had more employees than the GB average in manufacturing sector – 18.7% compared to the GB's 14.5%. Secondly, Welsh industry was marginally more productive than the employee share would suggest; Wales had proportionately 29% more FTE employees than the UK, but the sector produced proportionately 35% more gross value added. This higher level of value added might be expected to contribute to a higher use of carbon energy.

Thirdly, and as important as the two other factors summed, Welsh industry appeared much more carbon-energy intensive than the UK average. Whilst having around a third more employment and value added than the average, the sector used *two* thirds more energy.

It is difficult to judge whether this energy hunger is a product of the specific industrial structure of manufacturing in Wales, or technological or production differences within sectors. As Wales had a number of very energy intensive industries in 2003 including. oil refineries and an integrated steel plant, the suspicion must be on the former. It is useful to examine a number of Wales' industrial 'champions' and key sectors to establish their prospects in a more energy scarce world.

4.3 Steel

Long a producer, coater and fabricator of steel, Wales retains a number of operations in basic metals including at Llanwern, Shotton and Pontardulais. Primary amongst these are the operations at the *Corus Strip Products* integrated steel plant, Port Talbot which produces steel and coke for use at the plant and elsewhere in Wales.

Steel is the most energy intensive industrial activity outside of the energy and petrochemicals. Corus, Port Talbot is the second-largest emitter of carbon dioxide in Wales (ranking only a little lower than Aberthaw), a direct result of the extensive use of electricity, natural gas and coal (for coke) in its productive operations.

[h] Whilst this analysis relates to direct fuel use, the story is the same if industry's use of electricity is also factored in.

Corus is seeking to reduce the energy dependency of its operations. For example n January 2008, Corus approved a £60m capital investment scheme at Port Talbot for the installation of a BOS gas recovery system, including ancillary on-site power generation and gas distribution. The scheme should lead to a 60% reduction in natural gas usage across the site and a 20% reduction in electricity purchased from the National Grid, cutting carbon emissions by 300,000 tonnes per annum (around 5%)[46].

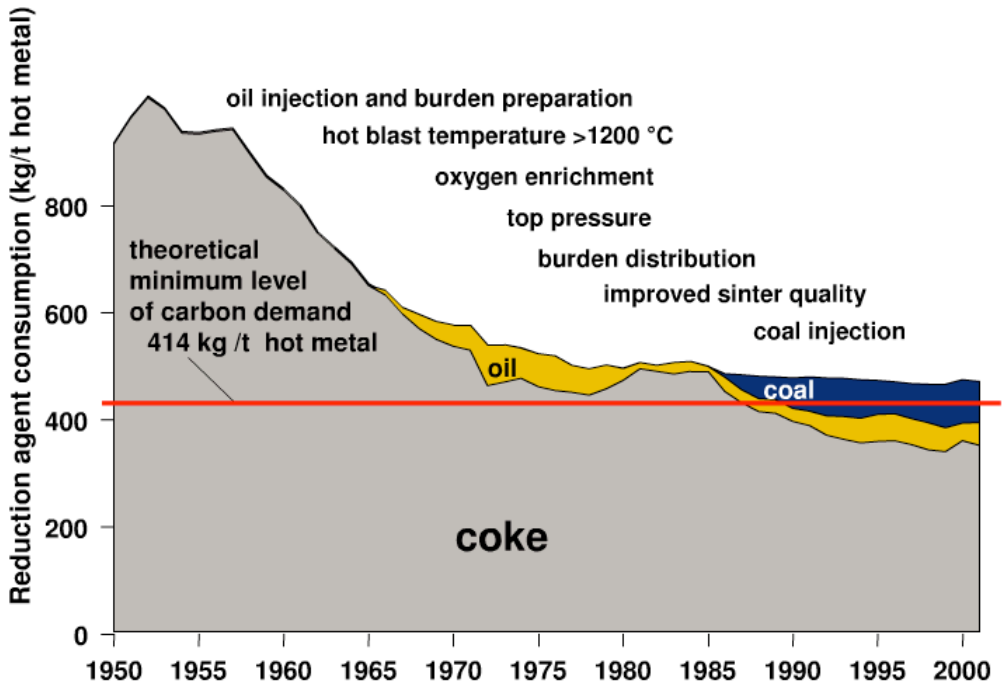


Figure 8 Carbon Materials Use in European Steel Production 1950-2000

Source: Corus

However, the prospects for improvements beyond this appear limited in the near term with steel plants already close to the maximum efficiency envelope (as Figure 8 shows). This is illustrated by the efforts of the European Ultra Low Carbon Dioxide Steelmaking European consortium (www.ulcos.org). The efforts of this group to cut the CO2 emissions of steelmaking by 50% in the next decade have focussed far less on the reduction of energy inputs, and more on the abatement of carbon through capture and storage. Although the technologies under investigation may cut carbon, they still require very significant energy input, in the form of natural gas, sustainable biomass, potentially hydrogen and/or electricity – all scarce inputs that will have to stretch very far to address the multiple uses to which they are being assigned.

In the short term, steel plants will remain heavily dependent upon fossil fuel inputs, both directly and via the electricity grid. In the latter case, relatively high UK (compared to the rest of Europe) prices may have contributed to the closure of the Teeside Corus steelworks. Corus claim the UK as having the world's highest prices for wholesale electricity in 2007/8 (Figure 9)

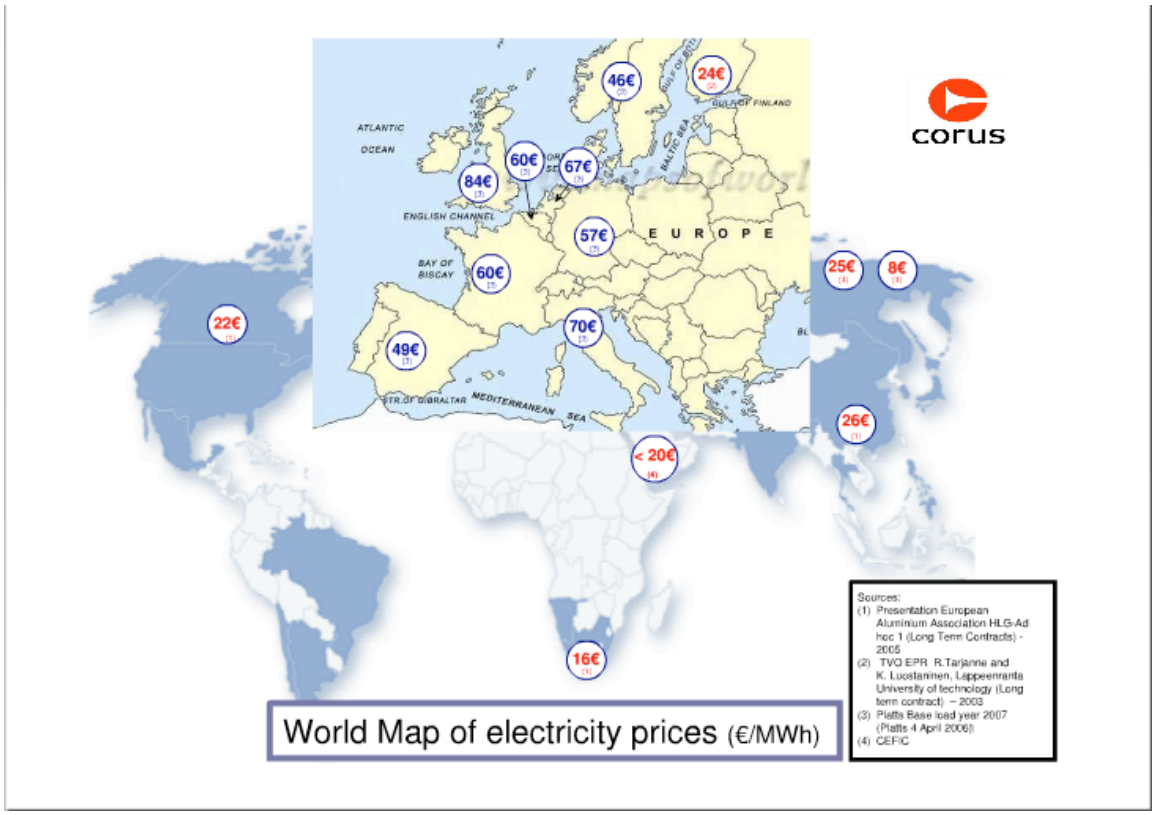


Figure 9 Electricity Prices for Steelmaking

Source: Corus

Earlier sections of this report have noted that the UK's electricity prices are unlikely to fall in the medium term. Over time, with the diminution of North Sea reserves, the position might worsen further as we import more gas for generation on expensive spot contracts. Whilst Corus in Wales largely avoided the 2009 round of redundancies and closures in the UK, the prospects of a worsening competitive position for steelmaking in the UK relative to both Europe and, particularly, South and East Asia as Indian and Chinese capacity continues to expand should not be discounted.

ULCOS envisage the potential roll out of some or all of their breakthrough technologies in 15-20 years (CCS permitting). It is too early to assess whether existing plants could be retrofitted with new technologies, although the need for new blast furnaces would mean the plants would effectively be new in any case. At this stage the likelihood of reinvestment in Welsh plants would be open to serious question (if any are still operational).

4.4 Automotives

Wales has around 200 companies in the automotive supply chain, and two major volume manufacturers; Ford at Bridgend and Toyota at Deeside, both making engines. 10,000 jobs are directly involved in the manufacture of motor vehicles and parts in Wales.

Recent investment at Bridgend (supported by a £14m grant) has secured the production of a new generation 1.6 low-CO2 'Ecoboost' engine, bringing the site to its full 1m unit capacity and safeguarding employment for the immediate future. A similar picture is evident at Deeside, with Toyota announcing that the first hybrid vehicle production in Europe will be in the UK. It will build the Auris Hybrid from 2010 at its Derbyshire plant – with engines to be made at Deeside[47].

Here, the prospects for continued industry success in Wales, in the short term at least, rest less upon the price or availability of energy than they do on the performance of the global parent in the face of recession. Both companies have benefited significantly from the UK government car scrappage scheme, but Toyota forecasts a return later in 2009 to the short time working that was instigated in early 2009 (along with a 10% pay cut for workers), but at time of writing announced the suspension of one of it's two UK car production lines with uncertain implications for Deeside[48]. It is fortuitous for Wales that it is home to two of the largest manufacturers by volume, and that Toyota and Ford have suffered less than some other competitors in 2008/9 (or at least started from a less-bad financial situation). The car industry however still faces substantial overcapacity worldwide, and continued restructuring and merger activity is extremely likely.

Moving into the medium term, a recent report from the Department of Business, Innovation and Skills (formerly DBERR) highlights the automotive sector as one which will need to respond to energy and climate considerations with 'transformational' change. Essentially, petrol-electric hybrids and low CO2 fossil fuelled vehicles are seen as a short term stopgap, with full electric and 'plug in' hybrids expected to take increasing market share beyond 2014[49].

This transformation will favour automotive companies that have large cash stocks, the ability to borrow, or growing sales/revenues to finance investment in technologies which may have long payback periods. Established large manufacturers have significant technological and innovative expertise, and home markets (e.g. the US, Europe and Japan) have the infrastructure to (arguably) ease the implementation of electric technologies given appropriate public investment. Moves to low CO2 vehicles will also be spurred by regulation, as the EU seeks to implement a fleet-average CO2 emission profile of 120g per km for new cars by 2020.

These markets are also, however, largely saturated, and established manufacturers are losing share to South East Asian competitors, even in advance of any exports from China. The spread and mix of sales between less developed countries (where markets are growing) and developed nations, and the relative nimbleness of companies in responding to a rapidly changing regulatory and consumer contexts will determine where excess capacity is lost from the motor industry, both in terms of company failure (or merger) and individual plants.

4.5 Aerospace & Defence

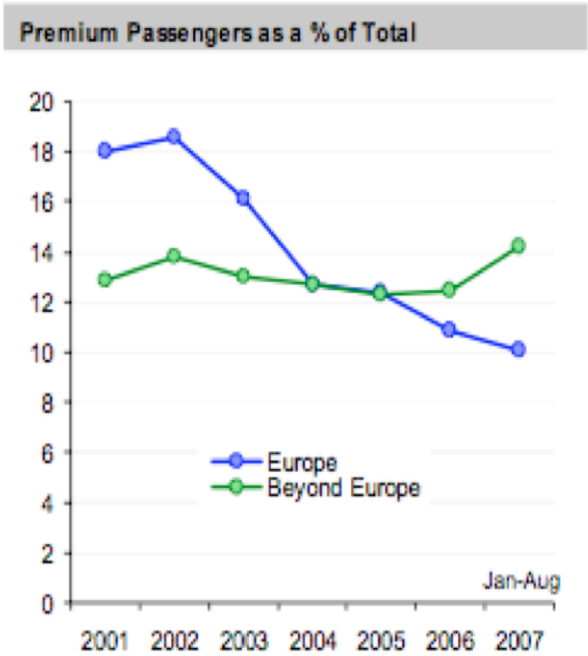
Wales has a significant aerospace industry, encompassing aeroplane manufacture in North Wales at Broughton (Airbus and Hawker Beechcraft) and maintenance of both commercial and military aircraft and engines in South Wales (NORDAM in Blackwood; GE at Nantgarw and BA Maintenance and the Defence Support Group at St Athan). Companies such as British Airways Avionics, Contour Premium Seating and British Airways Avionics provide ancillary services. Meanwhile, General Dynamics manufactures battlefield communications equipment. The sector directly employs almost 10,000 people.

Much like Steel and Automotives, the sector is characterised by the domination of non-Welsh companies, although here BA and DSG bring an element of British ownership. Again, companies are part of global logistics and support chains rather than producing final products.

Even before the credit crunch there were strong indications of the importance of energy prices for profitability and sales in the airline industry. 2007 was generally a good year for European airlines despite increasing energy costs, but this was driven by fuel hedging and substantial increases in passenger numbers, both of which were recognised as unsustainable very early in 2008 (i.e. independent of the recession)[50].

The recession has exposed the frailty of both minor and major airlines, with a number of smaller operators entering bankruptcy, and, critically for Wales, British Airways posting a loss of £150m for the second quarter of 2009[51] - and with its chief executive publicly debating the airline's viability under current trading and cost conditions.

A return to 'normality' – i.e. the trading conditions of pre-2007, with relatively low energy costs and strong (and rising demand) is probably necessary for BA to survive in the longer term. Its 'semi premium' business model appears unsuited to trading conditions, with the airline losing even blue chip customers (such as BP and the PM) to cheaper airlines, and unable to substantially cut production costs.



Source: www.aea.be

Even if input costs were to remain low, Europe may be close to demand saturation for air travel despite the UK government's optimistic 'predict and provide' approach to airport infrastructure. Levels of disposable consumer income (and indeed consumer confidence) in many European countries are unlikely to return to pre-2008 levels, given that tax levels must rise substantially and quickly to repair the poorer economic balance sheets consequent on expensive market interventions and reduced tax revenues during 2008 and 2009. Couple this with actual or promised investments in a number of European countries in high speed rail, including the UK, and the prospect of increasing consumer demand in the sector looks very uncertain.

Unfortunately in addition the prospects for inexpensive air travel to be viable beyond (or even remain at) 2007 levels are bleak. IEA forecasts of crude oil availability suggests that costs for airline fuel (kerosene) will head sharply upwards long before 2020.

Meanwhile, climate change action will substantially change the regulatory environment. Airline fuel is currently free of excise tax or VAT, but given airlines' rapidly growing contribution to climate change emissions (and the probability that aeroplane emissions are 'worse' per kg than ground level emissions due to radiative forcing[52]) this may be subject to change (although with this subject to at least EU wide and possibly global agreement). Additionally, European airlines will form part of the EU carbon trading mechanism from 2011, with potential implications for both their global competitiveness on intercontinental routes, and for their per-unit cost of sales and prices.

Prospects for airlines will have direct and indirect implications for employment in Wales, both immediately and should lower volumes impact upon aircraft maintenance and orders. The FT report that aeroplane orders collapsed in 2009 and Airbus is preparing for lower production. Although earlier orders kept Airbus (just) in profit in 2009Q1[53], but with aircraft orders typically lagging the economic cycle, outlook beyond that is very uncertain. Added to this, internal delays and mismanagement on both the A380 and A400M projects bringing significant further worry (the latter, a military transport is apparently so overweight it is unable to carry a modern armoured vehicle). Airbus is then another company that desperately needs to see a revival in air passenger transport as soon as possible. Whilst the prospect of disappearing low-cost flights may lead in the short term to increased consumption, further volatility in these final markets will not help longer term business viability.

The defence element of this sector is of course linked more closely to governments' spending than consumer behaviour, which is itself a political and economic/financial rather than energy cost-dependent activity. It is worth noting here however, the continuing decline of aircraft maintenance activities at DSG St. Athan which are to be replaced onsite by the Metrix defence training college (although with this latter development now subject to debate given future UK budget constraints).

4.6 The Prospects for Wales' Industrial Champions

Changes in the cost and availability of energy might have significant impacts on specific sectors and companies in Wales. There are some similarities and common themes that emerge, together with clear differences. A central challenge here is that Wales has a very limited presence in 'final products'; rather sitting somewhere within logistics or supply chains – and hence essentially invisible to the customer – and of course with little local ownership. It is difficult to think, in of any of the sectors examined, of a product which is positively associated with Wales by consumers, and hence where production might remain here despite long run core costs being uncompetitive in pure financial terms.

There are two factors which will decide whether these key sectors will remain so for Wales. Firstly, are core companies well placed to survive and thrive in rapidly changing business, cost and regulatory environments; and secondly, how likely are they to (re)invest in Wales, should they survive.

On the first question, Wales has so far been lucky. As the UK appears to hit the bottom of the recession (in growth terms) none of these major players has faced the challenges to their existence experienced by some of their rivals, although trading conditions for all have been extremely difficult. In the longer term, prospects may be uncertain. Steel, automotives and aerospace are all mature industries in Europe, all large consumers of energy (either in the production or operation phase) and all likely to face very significant regulatory and cost challenges because of this. In each case, due to the necessity for Western countries to cut climate emissions earlier and more deeply than less developed nations, and due to likely continuing higher energy costs, the competitive position for each of these European sectors will worsen compared to fast growing operations in India, China and elsewhere.

How long production will remain in Wales, even if parent companies survive, is of course uncertain. Recent investments at Corus Port Talbot, and in 'bridge' engine technologies at Ford and Toyota are welcome. However, history has shown us that the end of the product life cycle is a dangerous time for Wales. The electronics sector here effectively did not survive the transition from tape-VCR and cathode ray tube technology to that of full digital camera/camcorder and Plasma/LCD televisions[i]. In these cases, significant required reinvestment in plant sparked a ground up assessment of future relative cost competitiveness, and Wales, as a high cost location that nevertheless competed largely on cost, could not win.

Moves to low-carbon steelmaking (if such a thing is possible) and full electric or fuel cell vehicles may provoke similar shifts in the location of production. In each case, Wales and the Assembly will have a very limited influence over decision making, with very limited ability to substantially alter the competitive playing field via the provision of grants and with integrated business support unlikely to be substantially different to that offered elsewhere. With energy prices in the UK amongst the highest in Europe and likely to remain so, and with energy set to constitute an increasing proportion of unit cost, the prospects of retaining our current industry base are limited to the near term.

[i] With one or two notable exceptions such as Sharp

4.7 Flexibility and Innovation in Changing Times

As well as the protection of existing industries and activities, changing production and consumption will of course bring substantial opportunities for places which are well placed to attract or develop new activities, and respond to changing requirements for goods and services.

The Assembly government recognises this (in common with most other regions in the UK, and indeed beyond). For example, the Assembly Green Jobs Strategy, launched in 2009 emphasises the importance of support for R&D, commercialisation and innovation in sustainable activities. The International Energy Agency meanwhile suggests that the decarbonisation of the energy and transport industries will require $3 trillion of investment to 2030[54].

The IEA sees responses to climate change as essentially technical, focussed around the reengineering of centralised power stations, investment in energy delivery infrastructures and in next-generation vehicles. Wales is unlikely, on current trends, to gain a substantial share of the activity associated with developing new technologies, materials and approaches to progress decarbonisation, having very few companies undertaking significant R&D in Wales in related areas. The exception is the opto-electronics group in North Wales, albeit tangentially, where PV technologies pioneered by Sharp may have a role in the renewable generation of electricity[j].

Wales' lack of a presence (so far) in sustainable technologies mirrors a general lack of activity in business research and development more generally. Only 1.4% of UK business R&D was performed in Wales, whilst the region has 5% of the UK population and 4% of UK industry gross value added. The figures (which are very volatile year-to-year) show limited evidence of a trend upward[55]. Meanwhile, research in higher education institutions was typically at the same scale as in businesses (fluctuating between £150m and £250m). In this case though, the proportion of the UK's R&D reflected the size of the Welsh economy at around 4%.

This lack of R&D does not reflect anything particularly notable about Wales, but rather reflects the nature of R&D carried out in businesses, which tends not to be in small, peripheral economies like Wales. Research by the OECD on the location of patent applications (probably a reasonable corollary for R&D) proves this point. Patent applications are geographically concentrated (Figure 10); they happen more in predominantly urban regions; and they are generally associated with a higher skilled workforce and higher labour productivity.

[j] Although with applications and efficiency possibly limited in Wales itself on a purely commercial basis, even compared to other renewables.

Meanwhile R&D more generally seems to benefit from proximity spillovers[56] – that is, R&D will tend to cluster where similar activities already exist, or there are significant academic or government research efforts. None of this evidence suggests that Wales is likely to see a significant increase in R&D activity.

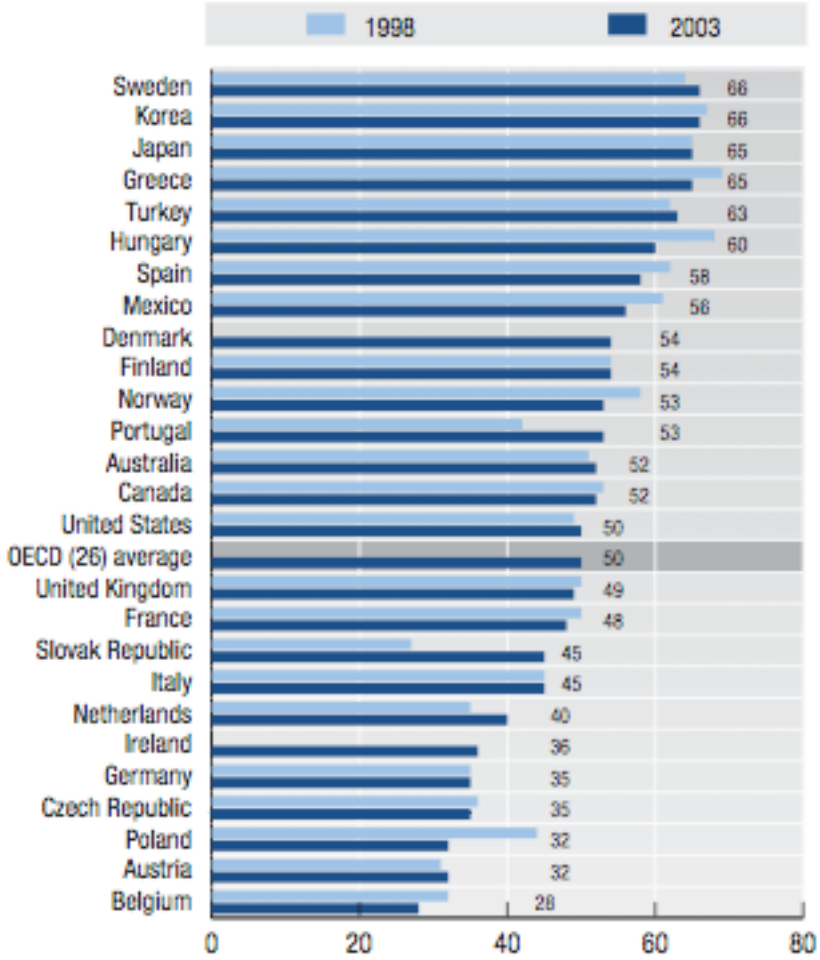


Figure 10 Concentration of Patent Applications (index OECD=50)

Source: http://fiordiliji.sourceoecd.org/pdf/regions_glance/07.pdf

This is not to suggest that Wales does not have a large number of interesting developments, companies and social enterprises that are making significant headway in dealing with the challenges of scarce energy. In fact, Wales can lay claim to an eco-Valley cluster that has built up around the Centre for Alternative Technology (CAT) outside Machynlleth (www.cat.org.uk). Many developments here (and similar organisations elsewhere in Wales) are perhaps more focussed on developing household and community-level responses to peak oil and climate change than they are developing international competitive advantage[k].

CAT itself has developed over four decades to become an internationally important centre for the development of alternative technologies (energy and otherwise), whilst providing an MSc in sustainable technologies, acting as a publisher of materials which address sustainability issues, and at the same time being an important attraction for tourists and educational groups. CAT has published the 'Zero Carbon Britain' report, which was amongst the first vision of a completely renewable (and non-nuclear) economy and society. This has, in 2009 given rise to the ZeroCaronBritain:2 series of seminars and the Convergence on Zero conference held in Washington DC alongside the Wales Smithsonian Cymru Folklife festival[57].

Whilst CAT's activities are small scale on an industrial level, the approach and structure is innovative. Moreover, it is completely rooted in the Welsh landscape and the social fabric of the Dyfi valley, and hence unlikely to be subject to the same location factors as more 'traditional' and cost-conscious economic activity. The ability of Wales to lever such currently niche (or at least non-mainstream) activities into larger projects with commensurately wider impacts may be a key driver of future success.

4.8 Summary

Whilst the prospects of Wales to retain its supply of carbon fuels and electrical energy for the medium term is probably better than other UK regions, in terms of industrial activity, Wales looks more vulnerable than most. A concentration of key companies in sectors that are high energy users, and which are facing transformative change poses many economic risks. These risks are multiplied by the inability of Wales, over many years, to develop levels of research, innovation, skills and higher order activities that might make the region more 'dynamic' and flexible within a rapidly changing economic environment.

[k] For examples of innovative approaches see www.dulas.org.uk/ and www.sundancerenewables.org.uk amongst others

The relatively narrow set of industrial activities undertaken in Wales (in terms of product and services development for example) are a result of decades, if not generations of industrial history, and unlikely to change within the tight timeframes required, despite the best efforts of the Assembly Government and partners.

Conversely, activity at the edges of the economic mainstream, and in areas that possess little economic advantage in a traditional sense do show that people and organisations in Wales can make a difference, by thinking and acting 'outside the box' and emphasising the importance of individual and collective responsibility. Understanding and benefiting from these processes may be a key element in sustaining prosperity in future, even more challenging environments.

5 Travel and Transport

5.1 The Other Side of the Coin

Employment opportunities that persist (i.e. are sustainable) in the face of energy scarcity and climate regulation is a necessary but not sufficient condition for a long-term successful region. The people of that region also have to be able to get to and do those jobs; products must be brought to market and various services accessed by the people of Wales.

This chapter of the report will assess the suitability and adaptability of Wales' travel and transport infrastructures for an energy scarce future – one in which private (and probably public) motorised transport is much more expensive – and where household disposable incomes are already under pressure from increased energy costs for heating, lighting and cooking.

Energy scarcity has different implications for different parts of Wales. Ensuring employment opportunities in the coastal cities of the South are accessible to the population of the Valleys will require different actions to ensure that rural productive and service systems are 'future proofed' in transportation terms. In both cases, however, current systems look extremely vulnerable.

5.2 The Problem of Transport

Chapter 1 showed that access to inexpensive fossil fuels is likely to be compromised very quickly, and with these fuels potentially subject to intermittent supply. In the case of energy generation, there is some comfort, in the short term at least, in the substitutability of fuels; if gas taps are closed due to political wrangling, coal can take up some of the slack (albeit with double the climate consequences). This in fact happens all the time as countries with varied power station fleets switch between different units in response to relative price changes.

This of course cannot happen with vehicles at any meaningful scale under current technologies. Increasing oil-product prices lead, mostly, to consumers of oil paying more. Some change in behaviour is of course possible – US citizens drove fewer miles in response to the petrol price increases in 2007 and 2008, and it is possible to choose smaller or diesel vehicles in the expectation of continued high prices[58].

Such behaviour change can only happen at the margin. A diesel, or substantially smaller vehicle might cut a family's per km fuel costs by 20%-30%, and more careful consideration of travel patterns might also help[l]. Beyond this however, increases in fuel costs result in decreased disposable income for households.

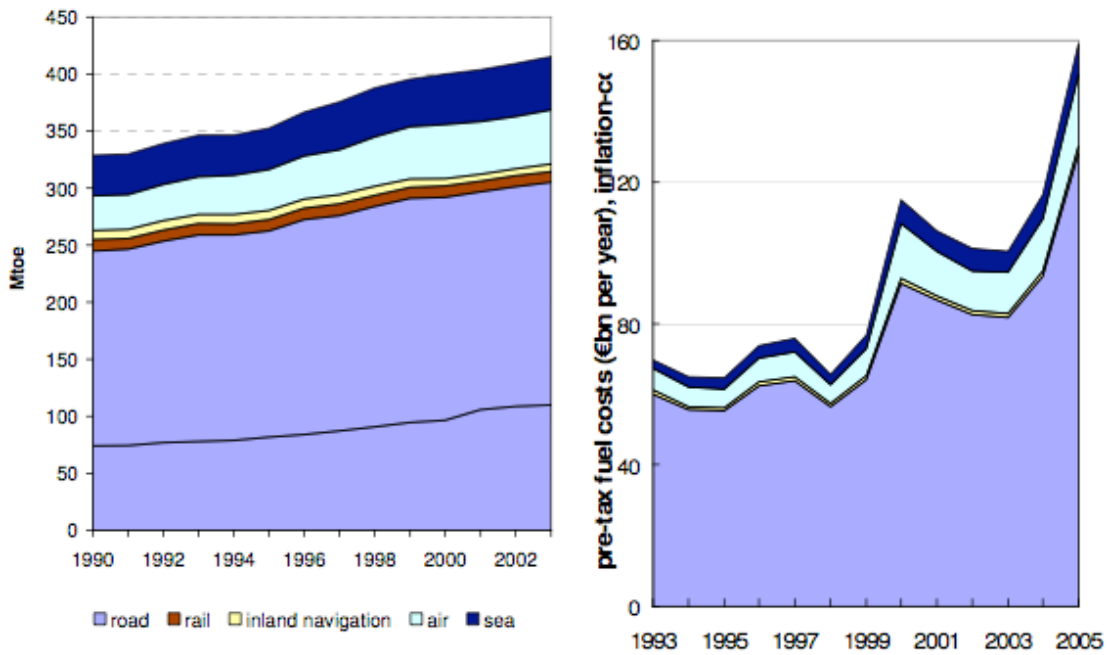


Figure 11 Final Energy Used in Transport and Pre-Tax Fuel Costs in Europe

Source: European Federation for Transport and Environment

Because of this lack of substitutes, transportation is the least sensitive to price changes of any oil use. In the short term then; over the next decade; increasing (and much more volatile) oil prices will translate to higher costs to consumers, and with bridge technologies such as low consumption engines and full hybrid petrol and diesel offering only partial respite. Such efficiency is of a far lower level than volatility already seen in oil markets: for example, the price of crude went from its average of $30 per barrel between 1987 and 2003 to over $140 in July 2008 – an almost five fold increase in five years – and is still, in the depths of the recession over double that figure.

[l] Meanwhile, most industrial users of oil for transport will of course already be using the most fuel efficient transport options in pursuit of profitability meaning increased fuel prices will be passed on in very large part to increased cost.

The 'bridge' technologies mentioned above all rely on the continued use of crude oil distillates for fuel. Other short term alternatives are unlikely to be scalable solutions; liquid gases such as CNG and LPG will be in increasing demand as heating and power fuels, and require investment in expensive distribution systems to reach vehicle fuel tanks (and different for each liquid). Suggestions to substantially increase the reliance on unconventional oils run into the same environmental, cost and climate issues as discussed in chapter 1.

Meanwhile, even the very limited use of first generation biofuels has revealed a host of social (food price) and environmental (climate emissions; water use) problems which are likely to preclude its widespread use. Second generation biofuels (such as bio ethanol from food by-products, or diesel from wood) offer some hope, but it is questionable as to whether there is enough biomass to supply transport industries given the scale of current use – especially as such biomass is also being identified as having a role in decarbonising electricity generation and space heating[59].

Beyond the next decade, the move to full electric vehicles holds out the prospect for sustainable personal mobility beyond that available on a bicycle – but only if the national grid can be fully decarbonised and, according to Mackay (ibid) doubled in size. Whatever level of mobility is actually available, it is almost a certainty that using over a thousand kilogrammes of metal, plastic and rubber to transport an 80 kilogramme perambulatory bag of water will become a very expensive business.

5.3 Commuting & Car Use in Wales

A higher proportion of commuting trips in Wales are by private car; 81% compared to a GB average of 69%. Even more rural areas than Wales were less car-dependent; for example the South West (76%) and East of England (74%). This car dependence is not restricted to work trips: In 2005-6 Wales had the highest proportion of all household trips in GB that were by car (73% compared to a GB average of 67%, with Northern Ireland at 75%). Wales also had the lowest proportion of children walking to school and the highest proportion driven to school of any UK region at this time[60].

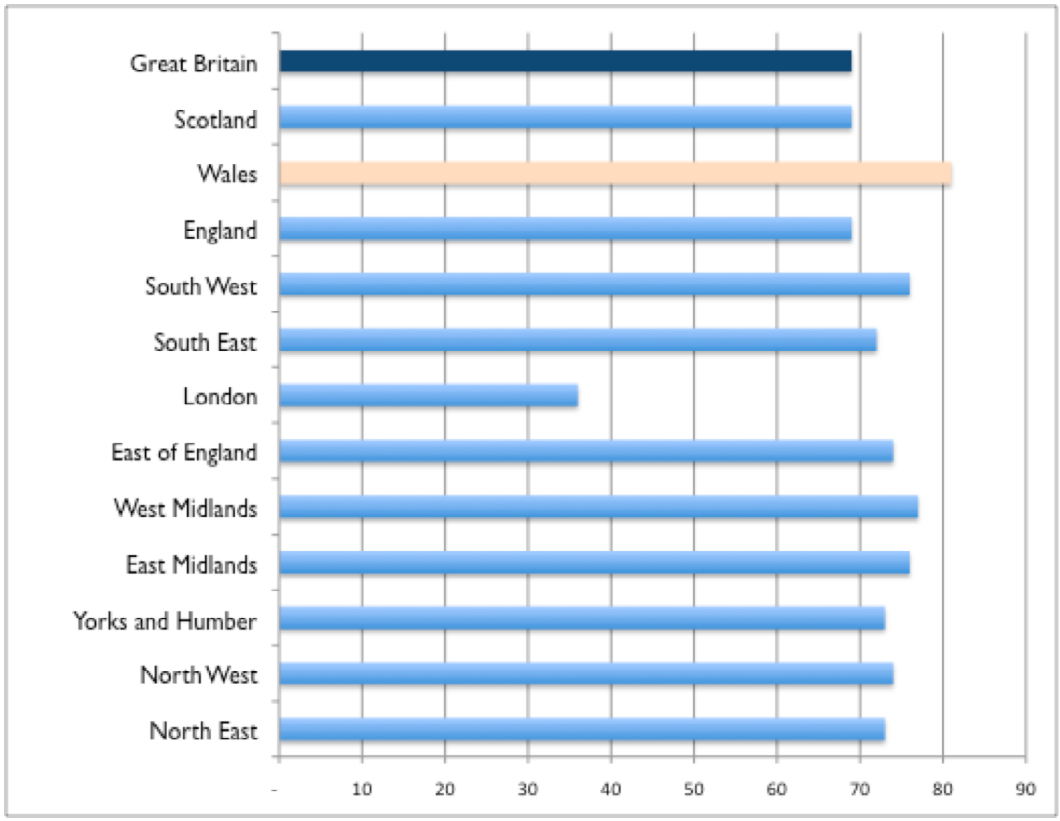


Figure 12 Percentage Commuting by Car: UK Regions, 2007Q4

Source: ONS Labour Force Survey

Some of these travel patterns are the result of geography and the dispersal of populations and services: for example, Wales has the poorest access of any region to hourly bus services close to home (and its children travel amongst the furthest to get to school). Whether these patterns are the result of socio-economic, cultural or purely geographic factors will be very important for policy development.

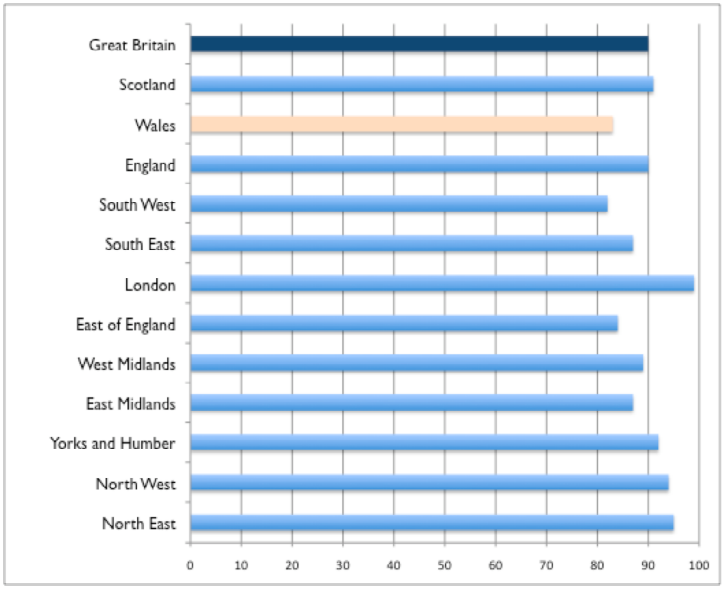


Figure 13 Availability of Hourly Bus Service within 13mins Walk of Home 2006-7

Source: Department of transport National Travel Survey

Proportionately less people in Wales work than in the UK, although that gap has narrowed over recent years. What has not narrowed is the gap in Wales-UK wage differentials, Wales remaining at about 13% below UK wage levels in 2008[61]. Clearly this has implications for gross household disposable incomes, which were 12% lower than the UK average in 2008 (and with West Wales and the Valleys 14% lower)[62].

The combination of the highest car dependence, with amongst the lowest income (household and GVA) of the UK regions is worrisome. This is not only with respect to access to work, but also services – especially for the one in six workless households in Wales. Transport and travel constitutes the largest single element of household expenditure, and the largest element within this is fuel costs. Relatively cheap motoring costs overall (despite increasing fuel costs) have encouraged the use of cars over relatively more expensive modes since 1990. The implication of the data is that Wales is perhaps worse placed than any other region to absorb higher travel costs, especially those than impact more on private car use.

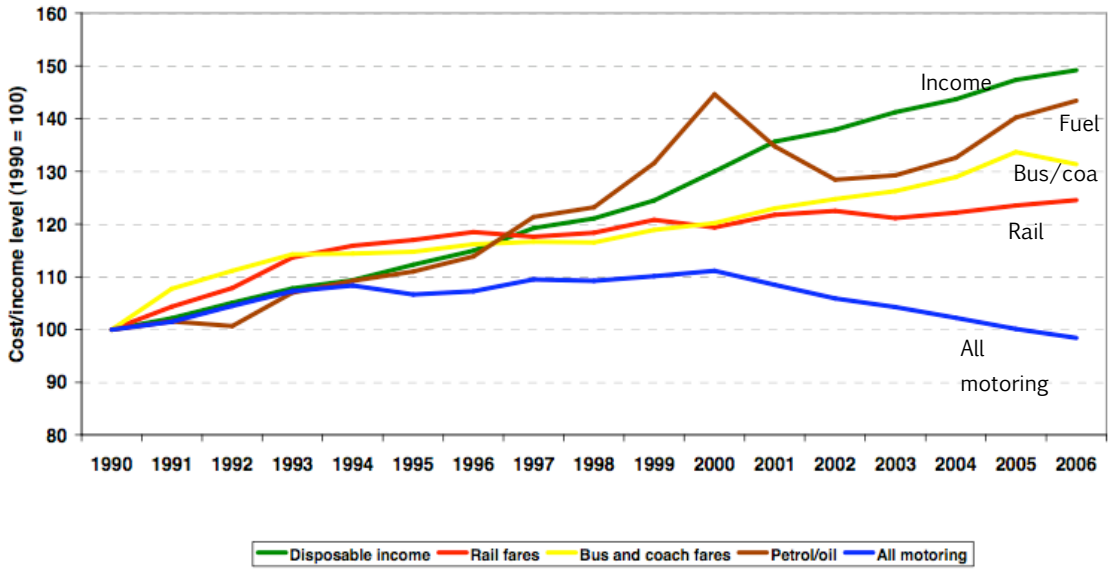


Figure 14 Relative Costs of Travel, UK 1990-2006

Source: http://www.bettertransport.org.uk/system/files/Transport_costs_and_carbon_emissions.pdf

In 2008, around 22% of Welsh households, 270,000, were estimated by the Assembly's Sustainability Committee[63] to be in fuel poverty, a 12% increase on 2004[m] and showing that the Assembly aspiration to eliminate fuel poverty by 2018 is probably unobtainable in a regime of increasing energy prices.

Fuel poverty is defined by having to spend more than 10% household spending on total home fuel use: thus, increases in travel fuel use will have no direct influence on this proportion. However, the 'double whammy' of increasing fuel prices for both home use and for travel means that in reality many Welsh households face substantial falls in real welfare as fuel purchases comprise an increasing proportion of household spending.

There is also an important economic implication here. With four-fifths of commuters travelling by car, increases in fuel costs have the effect of lowering the real wage. It is more expensive to travel to work, hence the differential between earned income and benefit payment decreases, encouraging more people, especially at the lower end of the income scale, to stay at home rather than work. As fuel costs increase, this effect will become more pronounced, especially, again, for lower wage earners potentially reversing gains made in Wales in the employment rate in recent years. The increasing real cost of bus and train travel over many years, even in advance of significant oil-price rises, does not hold out much greater hope for non-car commuters.

5.4 Freight Transport

Well over 80% of freight tonnage moving within, to and from Wales travels by road[64], slightly more than the UK average and substantially more than the EU (75%), with a number of continental countries using inland waterways with a far higher intensity than the UK (Figure 15). The intensity of freight movements in the UK (compared to GDP) has dropped substantially since 1995, far more than in other EU countries, with this possibly related to falls in manufacturing output in the UK over that time. The relative concentration on road freight in Wales implies substantially higher energy costs and carbon emissions per tonne-kilometre (although estimates vary due to differing fleet types).

[m] And with heating fuel prices in Wales substantial higher than in England.

Country	Road		Rail		Inland Water		Pipeline		Total	Ratio*
Wales	8	84%	1	10%	-	-	0.5	6%	9.5	-
UK	149	82%	20	11%	-	-	12	7%	181	85
Belgium	40	70%	7	12%	8	14%	2	4%	57	95
France	274	78%	50	14%	7	2%	21	6%	352	94
Germany	353	69%	75	15%	65	13%	16	3%	509	105
Portugal	15	88%	2	12%	-	-	-	-	17	118
EU	1,392	75%	242	13%	125	7%	87	5%	1,846	100

* Ratio of tonne-km to GDP, indexed to 1995 (=100)
Source: Estimated from WAG, DfT & EU statistics, 2004 [2003, million tonne kilometres]

Figure 15 Freight Movements by Mode

The share of freight taken by rail in the UK fell to an all time low of 6% in the mid 1990s, but on latest figures its share has increased to around a tenth. In Wales rail freight is very concentrated by commodity and geography, notably involving the carriage of steel, cars, petroleum products, aggregates and coal around South Wales (only part-coincidentally, the products of some of the key sectors discussed in chapter 4). Indeed, for the UK as a whole, the movement of coal by rail has accounted almost completely for that mode's increased share.

This concentration of rail freight on a relatively few products (and indeed companies; with mirrored on a much smaller scale in a North Wales corridor) implies that elsewhere in Wales, and for most other commodities, freighting by road is almost completely dominant. Indeed, the Assembly's transport strategy 'Connecting the Nation' suggests that for much of Wales, topography and transport infrastructure make road freight the only option (albeit often here not a costless one with many rural roads unsuitable for heavy traffic).

Here, then, Wales appears vulnerable to increased energy costs – in terms of both the prices paid for goods coming to Wales, and potential loss of competitiveness for Welsh companies that cannot shift away from road freight as fuel costs rise.

The freight sector also highlights the more general vulnerability of productive and distributive systems to interruptions in key inputs, such as fuel. *Connecting the Nation* notes that "large sectors of industry and commerce are reliant on the efficient transport of freight on a day to day or even hour by hour basis". The point made here is that road delays that affect trucks can bring significant economic cost.

A more general point is that the supply of goods and services to consumers, including those that address basic human needs, is wholly reliant upon a road freight sector that is itself wholly reliant upon the continuing supply of diesel oil, and with interruptions to that supply having and immediate and potentially disastrous effect. We are not talking here about 'the oil running out', but rather interruptions in the supply of a geographically concentrated and diminishing resource, whether this be the result of political argument, terrorism, or a refinery outage.

It could be argued that the supply system for diesel is sufficiently dispersed and robust to make such interruptions unlikely. However, as the fuel duty blockades of 2000 (and the phantom blockades of 2005) showed, hoarding, panic buying and widespread disruption can occur with relatively little actual threat of supply interruption. The reaction to an inability (rather than unwillingness) of hauliers to continue smoothly supplying the needs of society, even for a short time, may be considerably more extreme.

5.5 Tourism and Leisure

The development of the Welsh tourism economy has been highlighted as offering a number of benefits for cities and, particularly, rural areas hard hit by the decline of traditional industries. In 2006 tourism is directly and worth around 5% of Welsh GVA and 7% of employment according to the *Wales Tourism Satellite Account.*

Like everyone else, tourists travel around Wales by car: more so than in the rest of the UK. Of all UK residents who took holidays in Wales in 2008, 87% arrived in their own personal transport, with around 10% using train, bus or coach. These compare with figures for the UK as a whole of 78% by car and 16% by train bus or coach[n]. Whilst the figures for Wales in terms of car arrivals are worse than for the UK, on a positive note very few UK tourists arrive (unsurprisingly) by aeroplane – in contrast, 10% of UK tourists visiting Scotland use this extremely energy intensive travel option.

[n] The GB Leisure Day Visits Survey for 2002/3 also reported slightly more tourist day trippers in Wales using the car; 76% compared to 73% for GB. Indeed this was the case for all leisure trips (60% Wales; 58% GB).

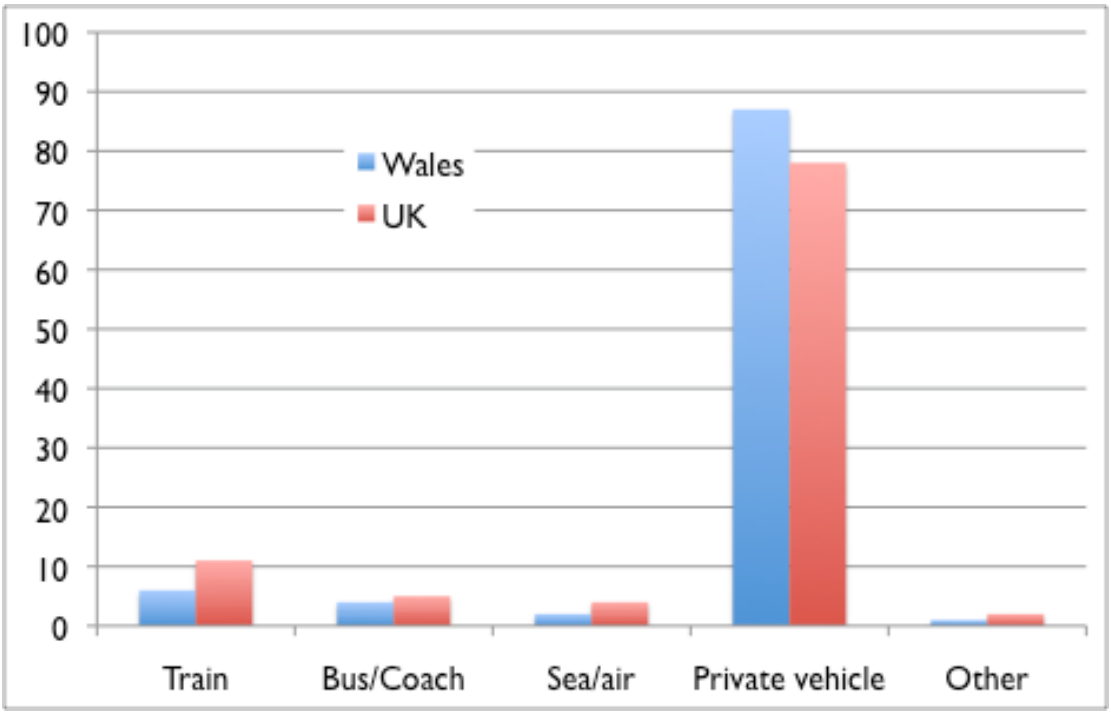


Figure 16 UK Residents' Holiday trips to Wales by Main Mode, 2008

Source: The UK Tourist 2008 www.tourismtrade.org.uk

As with many other elements of road travel, tourists' choices to drive are driven by a lack of timely and convenient alternatives and, in this case, the type of product on offer. Only 12% of holiday trips to Wales are to urban destinations, compared to 32% for the UK overall. Again, the pattern of behaviour in Wales suggests a higher level of energy-cost and climate vulnerability, with the seaside and rural destinations favoured in Wales far harder to serve efficiently with public transport.

The issue here, however for the short term is not whether the overall profile of tourism is more energy intensive than the UK as a whole, but rather whether Wales can compete with 'like' offers elsewhere in the UK (the vast majority of tourists who visit Wales are UK residents and hence likely to be comparing holiday offers within the UK). Here, some elements of Wales' tourism offer might gain from increased energy costs. For example the outdoor, mountain and activity tourism will compete with alternatives in the North of England and Scotland, which are further from most major UK population centres and hence may become more costly and troublesome to visit as travel costs increase (for example in short-haul air).

5.6 Summary: A Particular Problem for Wales?

The geography of Wales will both hinder, and potentially help adaptation to a high energy-cost and thus travel constrained Wales. The downsides are clear: for much of the country, geographic dispersion, an unhelpful topography and resultant limited transport infrastructure means travel is both necessary and difficult. Without significant subsidy or technological development on a radical and timely scale, many rural communities face very substantial challenges, potentially as soon as the next few years. On the upside, the linear development of many valleys communities holds out hope of efficiency in public transport.

Meanwhile, urban and Valleys' households that may struggle with home energy costs will be faced with the 'doubly whammy' of increasing transport costs – with again, serious results should this impact on access to basic services and to employment.

Whilst Wales shares some of its human-geographic characteristics with other UK regions (e.g. the South West and Scotland), the challenge of protecting the viability of vulnerable communities is possibly greatest here due to our unfavoured economic status. The news is not all bad however. For example, the linear characteristics of many Valleys communities, pointing South to the coast, means that in terms of public transport they are potentially 'easy to service' commuter conurbations. The recent moves by the Assembly to improve the Valley Lines rail infrastructure and services (including the reinstatement of two passenger lines) hints at the potential here, although modal shift will need to be far in excess of the already welcome improvements (and costs contained) if commuting travel is to be 'future proofed' to any degree.

Meanwhile, whilst increased travel costs are a threat for rural communities, they may also provide an opportunity. Increased costs of transport (or intermittency of fuel availability) may mean that local products and services become more competitive than those which arrive from afar. The processes and structures necessary that would allow for a rebirth of the rural economy following 'relocalisation' are too complex to discuss within this report, but the potential should not be ignored. Ty Tanglwyst Dairy (www.tytanglwystdairy.com) provides good example of this as does Aberystwyth University's decision to internalise the production and sale of all its meat products[65].

It is clear that in terms of transport infrastructure investment, there is a partial trade off between investments in what people use now (fossil fuelled cars, road freight) and those we might be expected to use within the lifetime of any developed infrastructure (electric trains and cars; potentially liquid gas fuelled or hydrogen buses etc). To pretend otherwise is hypocrisy. Here, the policy of the Assembly Government will be critical in determining whether we move ahead of the UK in securing a resilient transport infrastructure (given our particular needs this must include better coordination of product distribution) or whether we lag behind, with implications for regional development and prosperity. This policy issue, along with many others, is examined in the next chapter.

6 Policy and Politics

6.1 The Increasing Importance of Government

The role that governments in the UK will play in enabling a constructive societal response to scarce energy is uncertain. There have been many welcome commitments on the part of the UK government and Assembly (such as the cutting of UK carbon emissions by 34% by 2020[o], or the 3% cut per annum post-2011 that is part of *One Wales*)[66]. At the same time, however, implementation routes are murky: witness the approval for the expansion of Heathrow, or the Assembly support for an M4 relief road around Newport (now abandoned for financial rather than ideological or environmental reasons): both options that if implemented would undoubtedly serve to increase net carbon emissions.

Whilst the direction of policy travel is open to question, its importance is not. Events since Summer 2008 have made it clear that notions of *laissez faire* policy for self regulating markets is seriously flawed where those markets are complex and hence lack transparency. The need for active regulation is even more stark in the area of climate change and energy scarcity: it is not for nothing that the Stern Review concluded climate change was the largest market failure ever seen[67].

Investment in the infrastructures that can power our society will require massive investment, and with payback times extremely long and dependent on regulation and relative taxation levels for different fuels and technologies. The roll out of new technology and behaviours across the UK is probably more a policy-dependent than it is technology dependent. It is not too far a leap to suggest that, even with its limited set of current powers (albeit with more in prospect) the Assembly can play a pivotal role in deciding whether Wales is amongst the first to embrace new approaches and gain first-mover advantage in developing energy-resilient economy and society, or, will follow the rest of the UK – as the combination of a lack of economic critical mass and business innovative capacity and reactive public policies might imply.

[o] From 1990 levels, which implies a far less radical cut from 2009 levels.

6.2 The Limits of Power

It is notable that the Assembly does not have core responsibility in a number of areas that will determine how fast regional economies can adapt to unstable and expensive fossil fuel energy supply. Primary amongst these is, of course large-scale power generation, which remains under the remit of Westminster and Whitehall, and where the Assembly cannot take a lead role[68] (unlike in Scotland, where full control over planning policy giver Holyrood an effective veto – and one that will be exercised as long as the SNP hold power[69]).

It is far from the case however that the Assembly has no influence over power generation in Wales. For example, DTI ministers found it necessary to write to Rhodri Morgan urging 'speedy resolution' for Miller-Argent's planning application to exploit Ffos-y-Fran opencast: without such a permission, Aberthaw might well have closed, changing the energy mix in Wales (and indeed the level of carbon emissions) significantly, and perhaps sparking an earlier debate here about the *future* generation mix[70].

UK-level debates around the future generation mix will have a strongly Welsh flavour, including whether Wylfa is home to a new reactor (or two), and whether the Severn Barrage is a preferred development, and in what form. Whilst the Assembly may have no direct lead in these key decisions, it is difficult to imagine their progress not being substantially influenced by Assembly policy (a similar picture emerges with respect to transport where an again-limited set of powers is insufficient to develop a truly integrated transport policy or system). If power for energy policy areas remains with DTI/BERR/BIS, the implications for Wales will be interesting to examine. For example, with the South West of England designated as the first 'low carbon' English region, there may be an incentive (despite the Departments' UK wide remit) to capture innovative low-carbon activities there rather than in Wales: an interesting discussion in relation, not least to tidal developments in the Severn Estuary.

In both these areas the Assembly is seeking extra responsibility, but it is not clear whether that responsibility will bring any actual policy differences. The actions already undertaken by the Assembly (along with other devolved regions) are outlined in the UK Government's *Low Carbon Transition Plan* of July 2009. Whilst the listed actions are certainly welcome the language is notably mainstream and non-threatening: for example, the development of low carbon industry is to be through the encouragement of emission reduction via *Flexible Support for Business* and ensuring Welsh companies are aware of opportunities in the relevant sectors. Modal shift in transport is to be achieved by improving provision of cycling and walking lanes, and emissions from car use to be cut by increasing occupancy levels, and encouraging eco-driving techniques.

Earlier chapters of this report suggest such carrots will fail to 'encourage' behaviour change at the scale necessary before energy scarcity does it for us – in an unpredictable and painful manner.

6.3 Acknowledging Opportunity Costs

There is a general point to be made about public policy approaches to energy and climate that are typified by the above: an unwillingness to accept the existence of substantial opportunity costs in the transition to an energy resilient region. In the absence of rigorous, swingeing and painful regulation or taxation (or wholesale conversion to eco-living reminiscent of a religious revival), the sunk costs, physical infrastructure and societal norms of Wales will tie us to existing patterns of production and life for as long as they are possible.

The prospect of such regulation being imposed at the UK or EU scale is remote (at least within the time frame necessary). The UK government is convinced that short term reductions in energy use can combine with gas imports to 'tide us over' to a nuclear, clean-coal and renewable future - although given that clean coal looks extremely expensive even if technically feasible, and that new nuclear (or the Severn Barrage) are solutions for the mid-to-late 2020s at earliest, the short term is actually quite long here. Meanwhile, the EU carbon trading system may, in Phase 2 actually trigger some change in production methods (this never happened in Phase 1), the realities of horse-trading at EU level means EU ETS will, despite its extension, be nowhere near radical enough to cut carbon emissions by the amounts needed, let alone encourage energy self sufficiency for Europe or most of its constituent regions[71].

The lack of urgency at UK and EU level derives in part from an unwillingness to impose what are seen as 'excessive' costs on stakeholders such as businesses and households (albeit with uneven application, as those living next to Ffos-y-Fran might attest). The debate around energy transformation has hitherto been unremittingly positive on the part of governments, highlighting economic opportunities (or the thousands to be saved through acting on energy efficiency) and leaving to one side the discussion as to how far the fundamentals of life will have to change as fossil fuels become far less available.

A corollary of this positivism is a reluctance to develop policies which impose obvious and immediate costs on business or households – policies which are nevertheless necessary should energy-intensive behaviours and production be dissuaded and low-energy behaviours be not just encouraged but made the default choice. The possibility of sacrificing some short term competitiveness - and perhaps with such policies even encouraging some companies and people to *leave* Wales - in search of longer term gain or 'buy in' for more radical action seems to have never been considered.

6.4 Energy Generation

Assessments of the appropriateness of the future generation mix for Wales (at least for the next ten years) depend in large part on value judgements. For example, liquefied natural gas can be seen as a 'bridge' fuel that will see us safely to a low carbon future, but also as a repeat of past mistakes, locking us in to fossil-fuelled lifestyles that are fundamentally unsustainable, and increasing our reliance on an ever decreasing number of uncertain suppliers whilst stemming true transition.

We cannot have it all. The development of the new 2000MWe power station at Milford and the continued life of Aberthaw (and its 7 million tonnes of annual emissions) will directly impact upon take up of renewables in Wales (beyond ROC compliance) in the immediate future as these power stations provide relatively inexpensive, abundant and reliable power in the immediate short term. What incentive is there to invest in smart grids, innovative dispersed generation and politically difficult energy from waste plants, when power is available at the flick of a switch?

The problem here is that the continued dominance of fossil fuels in upcoming years may lock us even further into a path of dependency, meaning that should supplies be interrupted or become extremely expensive, the window for investment in truly large scale alternatives may have passed – in both financial and climate terms. In this scenario, those who suffer most are the poorest households in Wales and potentially, Wales itself as one of the poorest regions.

One does not have to take a position on these value judgements to agree that energy policy in Wales needs to be far more complex and holistic if it is to be fit for purpose. Currently, there is very little discussion in energy 'route maps' and strategies regarding how different generation methods fit together in terms of complementarity, substitutability or cost. Without this, no assessment can be made of how likely take-up of renewables will be beyond purely regulated levels.

In the meantime, our level of dependence on uninterrupted supplies of fuel for electricity is absolute, for example with a far lower capacity for gas storage than most other European nations (a legacy of our former self-sufficiency) and an ever increasing reliance on imported gas. The risks associated with this dependency are nowhere made clear in regional policy.

6.5 Towards Low Carbon Industry?

Wales has an aspiration, along with many other regions, to develop a low carbon economy. At the moment, it remains only an aspiration, with industry far more (carbon) energy dependent than the UK average, and with its largest energy user, Anglesey Aluminium closing ironically enough because of the cessation of its source of low carbon energy.

Section 4.2 suggests that a healthy dose of realism is necessary when considering this aspiration. There are very few policies extant in Wales which will encourage industry to 'green' more quickly than anywhere else in the UK – although our exposure to high energy costs may do the job for us sooner than we'd like.

There is a more general point to be made here regarding Assembly economic development policy, again relating to opportunity costs: £14m spent supporting re-investment at Ford or £28m at Airbus cannot then be invested in truly low carbon, sustainable or energy resilient activities or products[p].

The identification of Aerospace and Automotives as favoured 'key' sectors in Assembly policy, and the continuing focus on these sectors (along with others that are currently high energy such as tourism and agri-food) sits uneasily within a green jobs strategy when Wales has access to none of the levers that might 'green' these businesses. That is to say, Welsh aspirations for a low carbon future are wholly dependent on the adoption of appropriate technologies (where they even exist) by businesses in these sectors – and then their roll-out to Welsh operations. History suggests a measure of caution here.

[p] The Assembly would argue of course that the Ford grant is to enable the production of lower CO2 engines in Wales. The defence for Airbus must be solely economic.

6.6 Travel and Transport

It is extremely difficult to wean people from their cars. A degree of modal shift is possible to encourage through the provision of improved cycling, walking and public transport facilities[72]. However, to really make inroads into the 80%+ of journeys taken by car in Wales, it is likely that significant changes to the relative costs of private and public transport options (together with the increased availability of the latter) is necessary – and not forgetting concerted support for walking and cycling.

In the only case in the UK where the urban landscape has been altered firmly in favour of public and non-motorised transport, significant modal shift has been achieved[73]. However, the London Congestion Charge only had an impact because it altered the *fundamentals* of the economic choice that commuters and others made with respect to transport.

Schemes such as the Sustainable Travel Town initiative in Cardiff may have an impact, particularly as Cardiff is a larger city than those trialled in England – meaning success here would be proportionately more important for Wales (in England, falls in car use of up to 9% were claimed). The reliance here, however, is on improving the provision of public transport (albeit in Cardiff in a ring around the city rather than in the heart), rather than making car use more expensive: again, relying upon a plethora of 'carrots', with no 'sticks' in evidence. The insistence of the Assembly that it will not toll any existing strategic trunk roads[q] effectively signals that it is unwilling to impose costs on motorists beyond those imposed by the UK government[74]. The prospect of modal shift occurring in Wales beyond any UK changes are therefore uncertain.

Policies to improve walking, cycling and public transport infrastructures in Wales are welcome. However, policies which rely upon the incremental improvement of facilities, together with making citizens aware of low energy and CO2 options (and the health benefits therein) can only have significant impact where there is an established and realistic alternative to car use, and this only over a period of years. Unless the relative-cost and convenience issue is tackled extremely rapidly in favour of public transport, the majority of Welsh workers and residents will stop using their cars for day-to-day essentials only when car use becomes economically unfeasible.

[q] The abandonment of schemes in Edinburgh and Manchester make it unlikely that any Welsh local authorities will move ahead on road pricing in the near term).

If this happens quickly, public transport services, even where available, will be unable to cope. Ramping up public transport provision by orders of magnitude whilst encouraging (or in some cases, such as in city centres, forcing) residents to use these modes would seem to be necessary if Wales is to function economically beyond peak oil. The appropriate policies are well known and proven - mandating priority bus and cycle lanes on arterial routes; high occupancy lanes; and car-free city centres; with urban congestion charging and road pricing providing the income to enable investment in lower-carbon transport. Unfortunately, much, if not all, of this appears currently politically unacceptable.

7 Summary: Energy in Wales' Economic Future

"Shell estimates that after 2015 supplies of easy-to-access oil and gas will no longer keep up with demand.

Jeroen van de Veer
CEO, Shell, 22nd January 2008

"We're seeing the beginnings of a bidding war for Middle Eastern oil between east and west,"

Dave O'Reilly
Chairman & CEO. Chevron, 15th February 2008

'There is no crisis."

Malcolm Wickes MP
August 2009

7.1 The Issue in Summary

Fossil fuel energy traded on global markets is to become far scarcer in the medium term. In particular, availability of easily recoverable and easily refinable liquid fuels will decrease at a precipitate rate for geological reasons by the mid-2020s at the absolute latest, and with the significant possibility that the 'peak' of conventional oil may come far sooner (or in fact, already be passed).

The behaviour of global energy markets in 2007 and 2008 suggest that once the absolute decline in 'easy' oil is priced in to markets, prices will respond quickly upwards, but with increasing volatility. These price increases will affect not just oil, but its substitutes, such as liquid and piped natural gas. Meanwhile, the increasing concentration of the bulk of resources in a few countries brings into question how much fuel will actually reach global markets at all, with nationalistic concerns and behaviour already evident amongst resource rich nations. Moves by Chinese national companies to secure access to energy through joint ventures and trade-for-aid deals may also diminish globally traded supply, although such developments are, as yet, relatively small scale.

Alternatives to conventional oil vary in usefulness and availability. The most advanced development of unconventional oil, in Canada, has seen some fuel come to North American markets. Here the potential may be to cover much of US oil needs (at a higher cost per barrel than conventional oil), but at the cost of very significant local environmental degradation and potentially much increased climate emissions. The exploitation of heavy oil in the Orinoco region and elsewhere may offer an alternative. However, despite the existence of these oils being known for decades, they have not previously been extensively traded due to a mix of economic and political reasons, even when conventional oil prices were very high. Unconventional oils may form part of a future energy mix, but even the most optimistic scenarios suggest that their development will take decades, leaving a significant time period where the world faces a significant shortage of liquid fuel.

In power generation, oil can be substituted for by a number of fuels including coal and gas. In the former case, the extent to which *high quality* coal is available globally is uncertain, and the costs and technical challenges associated with carbon capture and storage mean the reliance on coal to meet increasing energy needs globally will expose us to the worst outcomes discussed by Stern and others. Gas supplies meanwhile may not peak until 2030 or beyond (depending on the level of global use going forward), but supplies are concentrated in three countries, only one of which can currently be classed as a reliable supplier.

Further into the future, the commissioning of a new global fleet of fission-powered nuclear reactors may provide low-CO2 energy. The safety, decommissioning and proliferation impacts of thousands of new reactors (and the availability of uranium under current technology assumptions to meet a radically increased demand) are uncertain. Again, timeliness is a problem.

Renewable resources will undoubtedly form an increasing proportion of the energy mix, but current market conditions and the adaptation of electricity infrastructures to 'always available' fossil fuels are slowing their growth at a time when their early and widespread development would appear rational.

Transport's dependence on oil and its distillates is almost complete. The replacement of oil with other fuels to service transport at current or ever increasing levels raises very significant substitutability issues: the biomass, natural gas or 'clean' electricity which might power vehicles in the future in each case faces already increasing demand in use for foodstuffs, energy generation, for space heating, and for residential and industrial electricity.

The above factors and developments might develop in a number of different fashions depending on governments' energy or climate policy, future energy demand (e.g. during recession), and the feasibility and availability of alternative energy supplies. However, the most likely scenarios involve far reduced levels of access energy between at least 2010-2020 and with energy for vehicular use even more problematic given its more limited set of substitutes. Beyond 2020 the position is more uncertain, and far more dependent on the development of new or innovated technologies and global climate and security conditions.

7.2 The Readiness of the UK

It is difficult to escape the conclusion that North Sea gas and oil may have been as much a curse as a blessing in preparing the UK for its energy future. On the positive side, the UK enjoyed substantial revenues since its exploitation in the early 1980s (although with these in steep decline) and has developed a substantial energy industry and associated knowledge. This, and the geological gift of now empty strata in the North Sea, may be valuable resources for carbon capture and storage development.

Conversely, access to North Sea resources means the UK has developed little infrastructure for storing gas, with capacity measured in days of use, compared to the months of some European neighbours. Because of its former energy independence, the UK has typically bought gas on 'spot' markets, rather than entering into long-term bilateral agreements with producer nations, as again have other European consumer nations. Whilst this may now change, the UK is unlikely to be a favoured customer for piped gas with any producer nation.

The push for the liberalisation of European gas markets (and the 'better functioning' of oil markets) is a key UK government response to energy scarcity. This works only as long as adequate gas and oil are available coming to market to serve consumers' needs. Even in efficient markets, declining or intermittent supply and increasing consumer demand lead only one way: to increased and volatile prices. The long term ability of the UK to buy its energy on international markets relative to other customers may have substantially decreased following the credit crunch and recession, which hastened already evident trends in the distribution of global prosperity and holding of wealth.

The reliance on markets as a solution to the energy problem arises from the unwillingness of the UK government to accept the possible early arrival of peak oil (or indeed peak gas or coal). The term is essentially missing from the Department for Energy and Climate Changes' strategic roadmap for a transition to a low carbon future. In Malcolm Wickes MPs' report to the PM on Britain's energy future, discussion of peak oil is relegated to a box and has no influence on any of the discussion therein – despite the fact that Mr Wickes attended meetings of the UK Peak Oil Taskforce, a business grouping that currently estimates global peak of oil productions will occur in 2014[75]. The likelihood that peak oil might impact upon the UK's prosperity or security in the upcoming decade has not even been considered and dismissed[76]. In terms of policy, peak oil is simply missing. The implications of this are potentially acute.

7.3 Is Wales Different?

With energy not a devolved matter, Wales faces many of the same access issues as the UK. The capacity to generate electricity is more than adequate if Wales can access fuel, and the development of the Milford Haven LNG terminal would increase this likelihood, as long as UK customers can compete with other consumers.

Wales has, as has been repeatedly noted, bountiful access to renewable resources such as wind, wave and tide. The sustainable exploitation of these resources must, however, be increased very substantially and incredibly quickly if these resources are to play any meaningful part in meeting the energy challenges of the next decade.

Wales is different in that its level of vulnerability to change would, on existing evidence, be higher than for other regions of the UK. Not only is Wales more manufacturing dependent, but its manufacturing is also more energy intense than the UK average.

Wales has a number of key players in very high-energy sectors which face radical global change in response to energy and climate drivers. The continued presence of these companies in Wales must be open to question, even though recent investments would seem to protect their short-term future here. Meanwhile, the lack of many final products made by Wales limits policy movement, for example in differentiation and moving to high value, innovative products. A lack of R&D capacity in Wales, together with our limited economic scale suggests that Wales might expect limited involvement in developing new generation energy, transport and other technologies to respond to climate and energy concerns.

Wales also faces higher than average vulnerability in other areas. For geographic and perhaps other reasons we are more dependent in Wales on private car use for access to work and to services. Meanwhile, levels of prosperity, income and wealth are amongst the lowest in the UK. The prospect of an energy squeeze affecting the low income and lower paid, potentially increasing both the cost of working (with implications perhaps for employment rates) and levels of fuel poverty must be worrisome.

Wales is also different in its political settlement. Like Scotland, London and Northern Ireland (albeit to differing degrees), Wales has the ability to influence behaviours; structures and indeed the content of public debate in ways which are unavailable to English regions. The potential to chart a different course also provides the opportunity to discover a better and more secure one.

8 Conclusion: What Should and Can Be Done?

8.1 Assessing Systematic Risk

The response of the UK government to upcoming energy issues is summarised by a belief in the power of open markets. Replacing inefficient state enterprises with efficient global companies in resource rich countries; encouraging further exploration; and freeing gas markets will be sufficient, in conjunction with squeezing our own North Sea gas, to ride the energy storm into a bright, low carbon future. If this analysis is correct, then Wales may have little to worry about

This optimistic reading has attracted sharp criticism; not just from environmentalists and those who study oil depletion, but also from a grouping of UK industry which includes Arup; Stagecoach; Scottish and Southern Energy; Virgin and FirstGroup. These companies include major players in energy and transportation: they may have something to gain from alarmism, but have far more to lose if the UK is unprepared for systemic changes in energy availability.

Following the 2008 collapse in derivative values, and subsequent credit crunch and recession consequences of *not* preparing for systematic risks are now well understood. There may be many lessons to learn from this episode;

- 'experts' may be deeply ingrained in established structures and attitudes and with and thus unable to consider what they see as low probability-high impact shocks;
- within an industry, personal progression may be dependent upon conformist behaviour and out of the box thinking de-incentivised;
- where intelligence is dependent on the reading of complex data (as in oil and gas reserves), and where that data is partial, information asymmetry problems can make the functioning of the market deeply flawed;
- divergence of risk-and-reward structures within markets mean that even where the possibility of risk is recognised, there may be no incentive to spread that information;

The existence of any or all of these factors in global energy markets may mean that even imminent disruptions in the functioning of those markets, and even their fundamental transformation, may happen with little or no warning for final consumers. Factor in nationalistic concerns (and substantial market power for national producers), and the mix is dangerous indeed.

8.2 Options for Wales

The devolution settlement leaves limited room for manoeuvre in some respects: the National Assembly, recognising this, is seeking more powers in critical areas. However, the reality is that even within the limited set of powers held by Cardiff, much *could* be done to prepare Wales more effectively for a higher energy cost world.

We face a problem however. The framing of climate and energy security issues as 'win-win' in governments' dialogue with voters, together with continuing climate-change scepticism amongst some, means there is little incentive for politicians to point out that radical changes to fundamental behaviours are needed (or indeed will be imposed by external factors). The unwillingness of the UK government to even admit that peak oil is a serious factor in future energy policy means that engaging in serious political debate on these issues in the Assembly might be even more politically fraught. The spectre of appearing 'anti-business' or of reducing Wales' notional regional competitiveness through the imposition of additional costs on businesses or households appears to restrict debate. This means that whilst actions taken in Wales appear worthwhile or even radical by UK standards (e.g. the 3% per annum target cut in climate emissions), economic policy, or public policy more generally, is doing nothing to prepare us for the changes we are likely to face, within the timescales we are likely to face them.

The following sections set out what actions might increase the resilience of the Welsh economy and society to energy scarcity. Due to the possibly rapid onset of energy crises, the focus here is on technologies that are already in operation, (but not necessarily to powers that are already devolved).

Clearly the following comprise a broad brush, generalised set of actions that take no account of electoral reality or public acceptance. It is useful to consider however the scale of the challenge in technical and administrative terms and the extent to which current policy does not even *approach* what is likely to be necessary.

Clearly, no investment is without cost. However, the virtual certainty of the need to decarbonise energy and transport systems in the face of dangerous climate change means investment in alternative energy sources and low-energy systems is unlikely to be wasted.

8.3 A Sustainable Resource Map of Wales

There is currently no systematic, holistic understanding of the potential for the landscape in Wales to provide an increased output of energy which is fit to drive land use policy (although TAN8 and the Strategic Search Areas for onshore wind move tentatively toward this idea). A typology of land within Wales could be developed with and type determined by a number of criteria: for example ecological and topographical characteristics; elevation; wind profile; distance from grid points and current ownership and usage. The development of this 'blank sheet' classification system, and its allocation to land parcels based on objective criteria and would indicate to what uses land in Wales could be put (and indeed where more than one use might be possible, such as wind turbines sited in biofuel planted fields).

Clearly this approach ignores wave and tidal power generation, which would need to be addressed separately (but with the UK government currently leading in these areas in any case). Important here is the ground-up assessment of land potential, unconstrained by existing restrictions or conventions. For example, TAN explicitly excluded wind developments in National Parks and other sites of natural beauty. Whilst it may be undesirable to develop such areas for some forms of renewables, less 'intrusive' types may be perfectly appropriate.

The land use map developed above would provide intelligence to guide a plan of action to rapidly increase non-fossil fuel energy supply. Sites with prime technical potential could be quickly identified and the information on ownership and current usage used to identify those sites where development is immediately feasible.

8.4 Direct Intervention In Renewables

Identifying suitable sites is not adequate for action: if it were so, Wales would already be well on the path to energy security. Rather, market, planning and perception barriers have stymied the development of local non-fossil energy.

Here, then the government of Wales and its partners will be required to take direct action to speedily ensure security of energy supply. Starting with the prime spots in its own estate, and that of partner organisations (Unitary Authorities; Education; Health organisations; Forestry Commission) the Assembly could rapidly develop energy sources which are effectively in house – owned by, and with the output used by, public sector organisations. (and potentially with a measure of trading between organisations and sites via the grid or directly).

This would have a number of benefits;

- prioritising the security of supply for public services which are likely to be most needed;
- investment in energy diversification to offset future energy price increases;
- contributing directly and forcefully to Assembly commitments on climate change emissions
- to act as a 'pilot' project for the development of a diverse, sustainable and secure energy generation system for Wales

As well as these direct benefits, there may be those that are 'softer' . For example, the direct involvement of government in energy generation will increase the knowledge and capacities of individuals and organisations. Academic expertise in Wales (widespread and varied in these areas) could be put to more direct use. Meanwhile, the benefit to Wales internationally of such bold moves, in terms of visibility and investment would be incalculable. Should energy prices (and climate taxes) increase rapidly, the Assembly might even find the investment economically cost effective.

The difficulties of such an undertaking, even on its own estate, should not be understated. For example, to mention just the most obvious;

- upskilling within organisations to meet the needs of project management,
- resistance from populations affected by developments (visually and in terms of construction activity
- liaison with National Grid over line usage
- Current land use planning policy
- UK government / devolution issues
- Investment costs

None of these issues renders the project technically infeasible. Some are within the purview of the Assembly Government. Others will require detailed negotiation with other bodies. Perhaps those most likely to stall the project most completely are public perception and initial costs.

In the former case, we are clearly a long way from public acceptance of widespread renewable installation. If we were to wait, then frankly it would be too late, In this instance a debate with the Welsh people on the urgency of the peak-resource problem is obviously needed, but perhaps not as much as the creation of 'political space' within which AMs as a whole can show leadership and progress these plans in the timescale needed. Here, it is difficult to see how anything other than wide support within the Assembly (in the best case, fully cross-party) will allow this to happen.

The second potentially most limiting issue is that of cost. Some actions (for example the planting, harvesting and processing of biofuels) could happen at relatively low cost and potentially with rapid payback. Other investments (such as large scale wind) will require a substantial up front investment that may not be narrowly cost effective in current conditions. Here the Assembly would need to define specific objectives and values to justify development (e.g. around cost-of-carbon & energy security) and, of course, find the money. This last point is returned to below.

8.5 Changing Travel Behaviours

Evidence from London suggests that many people will substantially alter their travel behaviours if private motorised transport becomes relatively more expensive, and if alternatives are practical and reliable. In Wales as elsewhere, motorists have benefited from a relative cheapening of travel compared to other modes. Reversing this trend would require the Assembly to make motoring more expensive (given that it already subsidises train and bus routes).

Road pricing has the benefit of both reducing energy use and climate emissions, and potentially providing revenue with which other transport options can be improved. The 'inelastic' nature of demand for car travel means that those who can pay will continue to use their private vehicles even if prices increase significantly[77]. Clearly, there is potential here for a nuanced policy to drive revenue increases which improve provision for the very worst off.

The potential for road pricing of the existing trunk network has been ruled out by this present government, but this, and/or urban congestion charging is the only realistic option for encouraging modal shift at the scale required. With prospects of a UK led scheme remote, and with little likelihood of UA-level schemes being brought forward, in the absence of Assembly action, nothing will happen and Wales will very likely endure the next energy spike more dependent on the car than anywhere else in the UK.

The barriers to action are common with those for renewable installation discussed above - although here with public resistance probably higher and thus wide political buy-in even more important. Again, whilst road pricing schemes can certainly be revenue-positive, the up-front funding for charging infrastructure and public transport improvements must be in place before revenue, meaning possibly substantial short term spending (and borrowing?) requirements.

Additional consideration should be given to making more efficient use of existing transport infrastructure and rolling stock. Studies have pointed out that increasing the cost of fuel typically drives commuters on to public transport at peak times – with high marginal cost and thus worsening the economic performance of public transport[78]. A key element of any future-proofed transport policy is thus the shifting of commuter demand from peak times using strong incentive and regulation to encourage flexible working (as well, of course as teleworking).

8.6 Opportunity Cost Decisions in Economic Policy

Current Assembly policy for economic development is the same as many other regions with alike situations: a focus on improving skills and labour supply, together with the provision of appropriate employment spaces, and grant aid as needed, legal and asked for. This approach has, unsurprisingly, done nothing to improve Wales' prosperity compared to other regions over many years; indeed decades.

Governments in general can only have a limited impact upon businesses performance and investment decisions; the Assembly even less so. The opportunity exists, however, for the Assembly to concentrate its economic policy on one goal and one goal only – increasing regional energy resilience. Through this filter a very different set of industrial and labour market interventions may arise. Generic interventions would be abandoned, and Assembly staff retrained with the aim of providing a single, focused service: helping Welsh businesses remain viable in an energy scarce future. Forward thinking businesses would have to demonstrate an understanding of how they can survive in a future that is based on low-consumption of energy and products.

Clearly this approach would involve the slaughter of many sacred cows; support for the North-South air link, generic grants to business and general business support amongst them. Some companies in search of grant aid that is not linked to low-carbon production might not reinvest or even leave Wales (although there is some debate as to how far grants make a difference to such decisions). Companies might not choose to come to Wales in the absence of an unquestioningly positive attitude to business investment of any kind.

These are not trivial concerns. However, the impact on actual regional economic performance is likely to be substantially less than that which would occur should Wales enter an energy recession at its current level of unpreparedness. It can also be argued that in engaging with companies more fully (indeed, only) on energy and climate issues, the scope and nature of economic activities undertaken in Wales may move more quickly towards one which is sustainable – providing greater long term gains than short term economic losses.

In this area, the Assembly is beholden to no-one, with economic development fully devolved. With Assembly support for business already subject to regular scrutiny in public forums, this is one area where a dialogue on policy renewal with the Welsh people might prove fruitful.

8.7 Funding the Transition

The transition to energy resilience will involve significant investment in the areas described, in addition to others not mentioned (for example, fuel storage and building reserves for times of interruption). Whilst some of the actions undertaken will provide revenues for government (and perhaps even profits), this will be in the longer term, with investment spending required up front.

The credit crunch and subsequent recession has left UK and hence Welsh public sector funding facing cuts in the near future. Again, in common with the rest of the UK, money will be hard to find, and investment will require the abandonment of other programmes. There are however a number of potential avenues which could provide funding for energy resilience interventions on a significant scale. These might include the following;

Switch from Existing Programmes	Substantial resources could be switched from generic business programmes without affecting core social or other programmes. For example, Assembly budgets for economic development and transport (DET) totaled £720m for revenue and almost £500m for capital spending in 2009/10[79]. This includes; ▪ £16.7m for innovation and technology ▪ £22m for 'enterprise' ▪ £8.5m for international & inward investment ▪ £15m flexible support for business ▪ £8.5m major (sporting) events.
EU Convergence Funds	The current EU Convergence period runs from 2007-13. Although much money has been allocated, the EU have proved flexible in allowing money to be redirected to respond to the recession, and with climate emissions reduction a key objective of ERDF intervention, a far tighter focus on energy actions would likely be feasible (at least for those monies remaining). The total allocation for the period for Wales is £1.4bn of Convergence Fund European money, enabling £3.2bn of interventions.
'Green' Bonds	The New Economics Foundation has already highlighted, as part of its Green New Deal the potential for local authorities to raise money by issuing 'green bonds'. These bonds, with low rates of return payable take advantage of the desire of people for low-risk investment (particularly following the credit crunch), and the growing market for sustainable investing. This may be one way in which the Assembly (or UAs in Wales) to raise funds relatively quickly[80].

Additional Taxes	At the moment Wales is unable to directly increase income or other taxes, although there may be leeway in to raise money other areas (for example through business rates, council tax or charging for services including roads). It is worth noting that a 1% increase in income tax in Wales would raise around £450m. A notional 1% increase in VAT on Welsh businesses would raise around £400m. These are significant sums for a targeted investment Not coincidentally, these are the absolute minimum levels of investment in alternative energy that Nick Stern considered were necessary to avoid dangerous climate change in 2006 (although he has since revised his estimate upward somewhat). It is worth noting that in suggesting a 'plastic bag tax', the Assembly has already shown its willingness to use fiscal tools to change behaviour for environmental reasons.

8.8 Conclusion: The Energy Resilience of Wales

Economic and energy policy is increasingly shaped in the EU, UK and Wales by the need to decarbonise production to respond to anthropogenic climate change. So far, however policies have failed to influence the structure of our economies sufficiently quickly to respond to the science. For example, whilst the Hadley Centre suggests that Western world emissions must peak by 2016 to avoid dangerous climate change, there is virtually no prospect of that occurring without wholesale and immediate changes to economic, energy and land use planning policy.

This is perhaps because climate change is a complex process, with long term and uncertain effects. The impossibility of 'seeing' these effects directly means that despite overwhelming scientific and government consensus regarding the causes and eventual severity of climate change, a public debate still continues as to its fundamental existence.

Further complexity arises because the worst of climate change effects are predicted to affect the global South and less developed nations. Radical climate change abatement is for Wales and the UK in part a *moral* action. As with all moral prepositions it is open to debate and different attitudes based upon the subjective values of individuals. These facets have perhaps provided an incentive for governments and political parties of all types to avoid proposing the radical economic and public policies that the climate change science demands for fear of electoral punishment.

Peak oil, and the coming energy crisis, is not like this. Wales is amongst the most fossil fuel dependent regions of the UK, and with the UK having increasingly limited access to fossil fuel sources that are reliable and abundant. The impact of the global peak of oil production will be felt directly in Wales, by the latest within 10 years, perhaps more here than anywhere else in the UK, and with an economy and population less well prepared to deal than in other regions with substantially increasing and volatile energy costs.

There are two basic approaches that the current (and the next) Government in Wales can take to the energy crisis. Firstly, it could rely upon the UK government to fulfil its responsibility and plan for sharply decreased imported energy with a credible, costed and holistic energy strategy. In this case Wales would of course have to hope that UK-wide actions are sufficiently sophisticated to protect prosperity in Wales in terms of direct interventions (given our different industrial mix and population dispersal), that UK and European energy markets respond effectively to rapidly changing economic stimuli, and that public finances recover quickly enough from the dire position in 2009 to appropriately fund actions directly and via the Barnett Formula.

The other option is to assume the worst: that one or more links of this chain will break, and Wales will suffer substantial economic dislocation and increased poverty following an energy crunch. In this case, it is the responsibility of the National Assembly to embark immediately upon a risk assessment exercise that identifies the key likely impacts of an energy crunch, and can suggest policies to minimize these impacts without the assumption that any current programme, sector, infrastructure or mindset will remain viable and appropriate.

Clearly embarking upon this route involves a difficult, complex and expensive journey, and probably the need to fundamentally reassess both the nature of party politics in Wales, and the quality of debate between Welsh politicians, civil society and *people.* It involves upsetting and inconveniencing many people.

The alternative for Wales is to avoid serious debate and radical action and to follow the UK government in trusting markets to provide solutions. However, the fundamental geographic and socio-economic character of Wales means that this failure in the duty of care will have the most severe consequences for our prosperity and wellbeing.

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