The Royal Society of Edinburgh
Inquiry for Scotland's Energy Supply

Submission From
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Context

An increasing number of individuals and organisations are predicting that global oil production is approaching peak, an event known colloquially as 'Peak Oil'. These organisations now include some of the world's largest banks [1] and multinational oil companies [2]. While there are still several organisations suggesting that global oil production will not peak for decades, Depletion Scotland is one of the growing number that believe Peak Oil will occur 2005 - 2007. Natural gas supplies for the UK are already becoming an issue with global peak in production expected 2020 – 2030 [3]. The issues for Scotland's energy supply and demand between the present and the year 2050 will therefore be dominated by declining oil and gas supplies for the entire period.

Consultation Questions

How should Scotland provide for its energy needs over the next 5, 15, 30, 45 years, in the context of the likely UK, European and global energy environment?

Scotland and the UK will probably cease producing crude oil and natural gas sometime within the next 20 years. The UK Dept of Trade and Industry until last year (2004) annually produced a graph showing actual North Sea UK sector oil production plus their estimate for future production. This graph shows that by 2020 UK North Sea oil and gas production is very low [4]. It would seem prudent to develop energy policies that are not dependent on oil and gas imports from volatile regions of the world. The replacement of declining domestic supplies of oil and natural gas may be too expensive or impractical. Specifically, if global oil supplies are peaking then there will be less oil available in future. These points are explored in more detail later.

It is worth noting that on 05 Sept 2005, Jeremy Cresswell, Editor of ENERGY published a front page article entitled "Operators Must Pull Out The Stops To Avoid UK Gas Crisis" [5]. Quoting Tony Mackay, of Mackay Consultants :

- UK Gas resources are in a precarious state, with output falling faster than either the Department of Trade or the UK Offshore Operators Association had anticipated
- Mr Mackay warns that official projections show UK production remaining in the range 85-100billion cu m per year for the three years, 2005-07, but the latest statistics show an annual decline of about 9%
- "If that continues, there will be serious supply shortages during the winter months," Mackay told Energy, adding that Britain's gas self-sufficiency effectively ceased last year and not this, as is commonly believed
- There are major pipeline and LNG import projects under way, but most of them will not be in place until 2007 or 2008. The solution will probably be a substantial reduction in the use of gas for electricity generation and an increase in imports of coal. The implications for the UK's balance of payments are frightening.
- The situation is so tight that UK North Sea operators have been warned by the Government that they must pull out all the stops in a bid to prevent gas shortages in Britain during the coming winter [winter of 2005/2006].

Recent opinions within the oil and gas industry [6] suggest that we have a short 'window of opportunity' to develop and extract new sources of oil and gas from the North Sea. Specifically, beyond 2020 the existing infrastructure will have exhausted its design life, particularly because of corrosion. Future discoveries would have to be large (eg. Claymore size [7]) to justify the expense of installing and maintaining new offshore infrastructure.

Should Scotland aim to be self-sufficient in energy in general, and in electricity in particular, despite trends towards interdependence within Europe?

Absolutely Scotland should aim to be self-sufficient in energy in general. It cannot be emphasized enough that this is not possible for oil and natural gas as described above, but it certainly is possible to a large extent for electricity. The current emphasis on electricity from natural gas, on which the UK is no longer self-sufficient and by 2030 will be entirely dependent on imports, must be seen as politically and strategically nonsensical. The nuclear option is not much better for exactly the same reason. Where uranium is not recycled, it has to be imported. Should the rest of the world decide to produce its electricity from uranium, and we believe this is imminent should blackouts become the norm, then it will, like oil and gas, become an expensive, if not scarce, resource.

Scotland must make much better use of its endowment of renewables combined with a transformation of our lifestyles that mean we require much less energy.

What are the possible implications and consequences for Scotland, and the UK, of becoming increasingly reliant on imported oil and gas for their energy needs?

Current UK combined oil and natural consumption is approximately 3.4m BOE (barrels of oil equivalent) [8] and, for the purposes of this initial estimate, consumption is assumed to remain constant. A further assumption is that UK is currently approximately self sufficient in combined oil and gas production during 2005 (more realistically the UK is probably showing a small overall surplus in 2005).

Prices quoted on Bloomberg as at Sept 13, 2005 are $63.5/bbl (Nymex crude) and $10.7/mmbtu (natural gas, Nymex Henry Hub). There have been recent press reports that UK has to pay in excess of $100/bbl oil equivalent to secure imports of natural gas during the forthcoming winter. On this basis (and given the tightening supply / demand outlook for oil and the increasing competition for LNG imports) the following combined oil / gas prices (barrels of oil equivalent) have been assumed:

- 2010 - $100
- 2015 - $100
- 2020 - $100

Predicting future market prices up to 15 years ahead can only be a 'best estimate' as lots of other variables including exchange rates, level of worldwide economic growth (or recession), customer demand in response to expected rising prices and level of energy efficiencies achieved etc. all will impact future prices. Nevertheless the above estimates when applied to future indigenous production forecasts will provide a good insight as to just how great the impact of ongoing North Sea depletion on the trade balance could be.

UK oil and gas production forecasts have been based on the graph based on DTI's own plot [4]. Given constant demand of 3.4m BOE the following calculations ensue:

Year	Production (m BOE/day)	Imports (m BOE/day)	Import Cost/Month (£bn) ($1.75 = £1)
2010	2.0	1.4	2.43
2015	0.8	2.6	4.52
2020	0.3	3.1	5.39

The above production estimates do not consider oil and gas production shown as 'possible' on the DTI's plot but a clear discovery trend has been established in the North Sea whereby the typical reserves of new discoveries are much smaller than in the early years of discovery and the trend is still shrinking. Put another way, no fields the size of Forties (oil) or Leman (gas) have been discovered for over 3 decades and based on oilfield experience in various parts of the world for the best part of a century, it is extremely unlikely that sufficient large fields will now be discovered to reverse the downward production trend. Furthermore small fields as are now being discovered tend to decline rapidly therefore the steep declines shown on DTI plot have to be considered as realistic.

As can be seen from the above forecast it would be prudent to plan for UK having to budget for oil / gas imports to surpass £25 bn per annum around 2010 and £50 bn pa around 2015. On this basis

there have to be major reservations as to whether UK as a whole could afford such imports even if a large number of businesses and individuals were still wealthy enough to continue with unrestrained consumption. For example it would be questionable whether UK could sustain this level of foreign currency borrowing especially as US will be in very much the same situation regarding energy import needs but with a much higher population hence it too would need to borrow multi-billion dollars per month. UK interest rates would need to rise significantly as a result and a major recession would be precipitated thus enforcing energy conservation (consumers simply would not be able to afford it). In the case of oil supplies there has to be a big question mark as to whether it would even be possible to source such imports against competition from virtually every other nation outside the few last remaining self sufficient oil producers. In the case of gas the only nearby nation with large surplus (Norway with estimated 44 TCF [9]) cannot supply anywhere near all of EU's demand, therefore it would be increasingly necessary for UK to source gas from remote producers such as Russia, Iran and Qatar (the former via very long pipeline runs and the latter 2 via expensive and energy inefficient LNG, liquid natural gas). The relative secrecy with regard to data released to the public domain for oil and gas reserves in these key producer nations is of additional concern, as are reports that 4 of the largest gas fields in Russia (from which supplies would be sourced) are already be in decline [10].

Given the possible scenario detailed above there also has to be a major concern over future UK electricity generating capacity. Present trends are to decommission at least half of ageing nuclear capacity by 2020 and to phase out many of the older generation of coal fired plants which are no longer acceptable environmentally. UK electricity generation by renewable energy is currently relatively miniscule and will still only be a minor contributor by 2020 (especially given interruptible nature of wind turbines). Former energy minister, Brian Wilson, recently estimated that up to 70% of UK power generation would be gas fired by 2020 and, of that gas, 90% would need to be imported [11]. If this forecast is anywhere near correct it represents an extremely undesirable position for future UK generating industry, not least due to the majority of nations with large surpluses of natural gas being extremely remote from UK and far less stable politically. No responsible Government should allow such a 'lopsided' primary energy source to develop for such a vital energy carrier as electricity. One other side effect of relying so heavily on natural gas (which is far from trivial) is that it would greatly increase the need for gas imports over and above what has been assumed above.

One of the aspects of the above scenario giving the most concern is that already it is 'too late' to mitigate the worst aspects of addressing the cost of energy imports and the security of supply, certainly as far as electricity generation is concerned. Even a decision taken today to return to nuclear power in a big way would not deliver a solution by 2015 given long lead times for planning and construction.

The big problem for UK electricity generation is that, without huge efforts to address the problem of consumption, few viable solutions apart from LNG imports exist. Coal is dirty and nuclear power is unpopular and the problem of extremely long term storage of radioactive waste has not been solved. Renewable energy sources are desirable but wind turbines subject to weather downtime and are starting from an extremely low base. Tidal power has been overlooked but is dependable and UK has a number of sites with high potential (Severn Estuary for example); tidal (and wave power) options should therefore be considered without delay.

Given that UK appears to have major supply bottlenecks ahead in a secure and affordable supply of natural gas for electricity generation and both industrial and domestic consumers we need to consider what happens in the event of peak demand not being met:

1) Gas supplies to industrial customers will be disconnected first
2) Gas supplies to electricity generation plant will be disconnected second
3) Gas supplies to domestic consumers will only be disconnected in the last resort (for safety reasons subsequent re-connection requires individual site visits).

Option 1) above will no longer achieve the volume of savings as in the past as much of UK industry has moved 'offshore' over the last 2 decades. It therefore follows that because gas supplies to domestic consumers can't be interrupted reductions in consumption will take the form of domestic electricity cuts instead (incidentally these also achieve reductions in domestic gas consumption as boilers generally don't run without electricity).

The issue of supply and storage of natural gas also needs to be addressed. A significant number of additional LNG terminals will need to be constructed and there needs to be large scale investment in

LNG tankers (which cost $250 million each). LNG terminals constitute a major safety hazard and there will certainly be large scale planning objections from nearby residents. Furthermore, UK currently only maintains natural gas storage amounting to 14 days' peak winter demand whereas several other major EU nations maintain up to 80 days' storage [12]. The low level of storage in UK was based on supplies from North Sea being extremely reliable and relatively well diversified. By contrast France and Germany, for example, did not have indigenous supplies and were thus forced to provide large scale storage as gas utilization ramped up. It will undoubtedly be both time consuming and expensive for UK to address the storage issue now but, as the switch to remote sources of supply is enforced by ongoing North Sea declines, there will be little choice in the matter.

We need to eliminate the 'short term thinking' which has been very prevalent in recent times. Energy and infrastructure planning needs to be based on a timescale in terms of decades – 'patching things up for the least possible cost until the next election' will virtually guarantee future energy crises.

Energy Supply

What is the feasibility, availability, reliability, sustainability, efficiency, capacity and risks of the different energy generation technologies?

Wind

Wind is powerful in that the total wind resource could supply all the UK electricity demand. Wind turbines have developed considerably in size and efficiency over the years to point where they are now mass produced and reliable machines.

Wind is an intermittent energy supply so a different use pattern would have to evolve. There is no available means of storing sufficient electricity to supply current electricity demand using stored wind energy.

A Warwick university study [ref 13] suggests that to supply hydrogen to fuel all current road vehicles would require wind turbines around the entire UK coast in a strip 6 miles wide.

Availability of wind resource does not mean that enough wind turbines can be constructed, or that they will be available quickly enough to offset declines in natural gas supply. Such a huge construction program would use a significant amount of energy and take many years. Oil price rises are currently being accompanied by rises in the prices of energy intensive commodities such as steel and cement.

The environmental cost of wind farms on every suitable site may not be acceptable.

Wave

Wave energy is powerful in that the total resource around the UK coastline could supply a large proportion the UK electricity demand. The equipment to capture this energy is still in early stages of development.

Availability of wave resource does not mean that enough wave generators can be constructed, or that they will be available quickly enough to offset declines in natural gas supply. Such a huge construction program would use a significant amount of energy and take many years.

Coal

Coal is polluting but also increasingly expensive. UK coal production is falling and imports are rising. The UK uses 55 million tonnes per year [14]. Coal production in the UK peaked in 1913 at 294 million tonnes per year, but by 2004 UK production was only 25.1 million tonnes [14]. The last big coalfield in the UK was Selby which closed in 2004 after 20 years of operation [15].
Prices for internationally traded steam coal imported into North West Europe was around £20/tonne in 2002 but has risen strongly since then to an average of £37/tonne in 2004. There is much coal around the world, particularly in the USA and China where production continues to grow. Import costs continue to be a drain on our balance of payments.

Coal is likely to be pressed into service to replace lost natural gas production both here in the UK and in the USA pushing prices much higher. Increased use of coal will contribute to climate change.

Oil

Oil is most valuable as a fuel for transport, agriculture and shipping. No other energy technology can come close to petrol, diesel and LPG as a convenient, cheap and reliable vehicle fuel. 98% of powered transport runs on oil. There is a huge investment in oil powered vehicles, vehicle manufacture, maintenance, fuel distribution and roads. Electrification of rail is a proven technology but shipping, agriculture, road vehicles and particularly aircraft are absolutely dependent on oil.

Risks to our oil supply are in turn risks to our economy and our way of life.

UK domestic oil production peaked at 2.684 million barrels per day (mbd) in 1999 and has declined by more than a third from the peak to 1.747 mbd for 2005 (Jan - June average, 1.616 mbd for June) [16]. The UK is moving from being a significant exporter of oil to being a significant importer of oil [17]. This has serious implications for our economy and our national security.

Oil may become more valuable as a lubricant and chemical feedstock in the longer term pricing it out of the market as an energy commodity.

Oil prices have risen sharply in the last few years from $10/barrel in 1998 to $70/barrel in September 2005.

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Natural Gas

Currently one third of UK primary energy is supplied by gas. Gas powers one third of UK electricity generation and more gas-fired power stations are proposed.

Natural gas production in the North Sea peaked in the year 2000 [4, 18]. By 2020 UK gas production will be less than 20% of current production. Gas production is declining in the rest of Europe and the four largest gas fields in Russia are in decline [10]. Gas production in North America is set to decline and many new gas import facilities are planned. India and China are increasing gas imports. With all this international competition for imported gas it is likely that gas prices will be at least as high as oil prices and there is no guarantee that enough gas will be available. The availability of enough infrastructure to transport international trade in gas is a key constraint. The current world LNG supply is only a fraction of what will be required in 2020. By 2020 world gas production is likely to be close to peaking, so much of the huge investment in infrastructure may be of little value after that point.

It is possible that UK gas prices may exceed UK oil prices in the future due to the constraints described above. Gas should not be seen as a cheap alternative to oil.

Big additional demand for natural gas to power road vehicles, or to replace coal and nuclear electricity generation are unlikely to be met. Maintaining existing domestic and smaller commercial demand will take all the gas that reasonable foreseeable imports could provide due to the constraints described above.

Gas may become more valuable as a chemical feedstock in the longer term pricing it out of the market as an energy commodity. Gas is used for production of most industrial hydrogen, useful as a stepping-stone to a hydrogen economy. From industrial hydrogen comes the large quantity of ammonia that is required for nitrate fertilizer that is essential to modern conventional food production.

Gas prices in the UK have risen sharply in the last few years from an average 15p/therm in 1990 to 35p/therm in 2005. Prices for UK delivery of gas in winter 2005/2006 are more than £1 per therm, which is equivalent to more than $100 per barrel of oil in energy terms.

We have gas supply lessons to learn from the USA. Average residential gas prices in the USA averaged approximately $6.30 per thousand cubic feet during the 1990s, prices for the same unit of gas reached $13.84 in June 2005 [19]. We should be watching the decline in gas supply in the USA and avoiding the mistakes they have made. In particular the decision to build many new gas fired

electricity-generating plants without making a rigorous forecast of gas available to fuel them. The success of US efforts to import gas as LNG will be relevant to our situation.

Nuclear Power

Nuclear power is very expensive. The consequences of accidents can be catastrophic. Dealing with the current accumulated nuclear waste will cost tens of billions of pounds. It is questionable whether this level of subsidy in construction, operation and decommissioning can be maintained given the likely decline in supplies of oil and gas and the potential for economic problems. The former Soviet Union can teach us lessons about dealing with a nuclear legacy at a time of economic decline.

Uranium must be mined and exists in finite quantities. Much of the energy needed to mine uranium currently comes from oil. As petroleum becomes more scarce and expensive, the mining process will likewise become more costly and will yield less net energy. Uranium ore exists in wide ranges of concentration in the earth, not all resources are viable sources of fuel.

The UK does not have any significant uranium deposits.

It has been calculated that if all current electricity generation in the whole world were produced from conventional uranium fuel, then known reserves of uranium would only last for only three years [20]. This limitation is masked at the present time by the fact that the electrical energy produced by nuclear reactors comprises only some 6 – 7% of the total energy use in the world [32]. Demand for electricity continues to grow around the world exponentially.

Bio-fuels As A Substitute For Oil

Fossil Fuel - The UK uses approximately 1.7 million barrels of oil per day, which is approximately 85 million tonnes (620 million barrels) per year. The UK uses approximately 100 billion cubic metres of natural gas per year which is about 85 million tonnes. Coal demand is about 55 million tonnes per year. Total fossil fuel demand is approximately 223 million tonnes per year.

Annual crop production - Total yield of arable crops in the UK yield about 23 million tonnes (dry mass) of wheat, barley, oats, rape seed and sugar beet products. This accounts for about 70% of all cropping on agricultural land [21].

If all this biomass could be converted into bio-fuel with 100% efficiency then it would still supply bio-fuel with a mass of approximately one tenth of the fossil fuel we use each year, and leave us without food. Efficiency of conversion will in reality be much less than this.

It should also be remembered that current agricultural yields rely on large fossil fuel inputs in the form of fertilizer, pesticide, tractor fuel, transport by truck and manufacture of machinery.

Wood production - The forest estate of the UK covers an area of 2.8 million hectares, or 11.6% of the land surface. The biomass which constitutes these forest contains about 150 million tonnes of carbon, which is roughly equal to one year of CO2 emissions from burning fossil fuels and certain industrial processes in the UK [22]. Trees typically take 40 to 100 years to reach maturity. The total biomass accumulated each year by forests is only a few percent of UK demand for fossil fuel.

Biofuels may have a limited role to play but they cannot replace oil.

What are the likely trends, and uncertainties, in the availability and cost of energy sources over the next 20/45 years?

In any forecast of the future the politics and economics will be as important as physics and geology. They all need to be considered as a coherent whole.

In 2025 UK domestic gas and oil production will be at less than 5% of current levels [4] unless production is deliberately shut in for strategic reasons. World oil production will have declined somewhere between 15 and 30% from the peak (in 2005 to 2007) [23]. Demand in some developing

countries may continue to grow. Demand in most developed countries will be declining. Competition for oil supplies will be fierce. This may result in prices at levels beyond current comprehension, or oil will be allocated outside of markets by direct control of resources. Some exporting countries may decide to stop exports and maintain a more self-sufficient economy.

Problems will be compounded by our economic system. In 2005 most companies and individuals are in debt to financial institutions. Many countries and governments are also in debt. If these debtors cannot grow or at least maintain their incomes or economies then they will have to default on their debts. Rising cost of oil gas and coal will force cuts in many activities resulting in recession or economic depression with rising unemployment and falling tax revenues. Large-scale financial crisis would delay or disrupt the process of adapting to a world of less oil and gas.

In a decline situation resources used for investment will have to be taken from a shrinking pool perceived to be in short supply. 'Fire fighting' measures like tax concessions will have to compete with investment. Political expediency will be set against rational planning.

There is real danger of vicious circles setting in, as shortages in fuel, transport, personnel or other resources combine to create greater shortages in fuel, transport, personnel or other resources. For example an initial shortage of diesel leads to staff failing to attend work at an oil refinery, maintenance work gets behind schedule further reducing the supply of diesel. In a modern industrial society relationships are endlessly complex and so more fragile than this simplistic example. Avoiding vicious circles of decline should be a ruling principle as the consequences are unthinkable.

Oil price rises are currently being accompanied by rises in the prices of key commodities such as steel, cement and coal. The costs of energy intensive commodities will continue to be driven upwards by the cost of oil and other energy. All of which will make investment in alternatives more difficult as oil become more scarce.

For practical purposes decline in oil use will be a process that continues indefinitely into the future. It is not a matter of moving to a certain stage and resuming growth or reaching some steady state of reduced oil consumption. Conservation of fuel or efficiency will be applied and will provide essential breathing space and allow some investment. but it is no substitute for true localisation to reduce the need for powered transport.

In 45 years UK gas and oil production will be effectively nil. World oil production will have declined somewhere between 40 and 60% from the peak in 2005 to 2007.

North Korea, the former Soviet Union and Cuba have all been through the experience of dramatically reduced energy use, particularly oil. The history of these countries can teach us lessons about what we should fear and what we should hope for in the future.

What are the economic issues of capital investment in the supply and distribution of energy that need to be considered?

Capital investment is currently focused on meeting continued growth in demand for energy; investment should be focused on adapting to reduced supply.

There are massive investments currently proposed to accommodate increased car use and air travel. In Scotland the budget motorways and trunk road improvements was £837m for 2003-04 [24] with the proposed M74 extension set to cost about £500m alone. The two airport rail links (Glasgow and Edinburgh) are reported to cost £750m. We continue to build suburban housing and out of town business parks and academic campus developments which are car dependent or difficult to serve by public transport, walking or cycling.

A typical government forecast suggests (for UK) growth in car travel of 33% by 2020 and air travel by 200 - 300% by 2030 [25]. These forecasts are absurd in the face of oil supplies that are barely keeping up with demand in 2005.

Energy consumption standards for new buildings are still below international best practice and much of the current housing stock is draughty and poorly insulated.

Investment should be focused on rebuilding our infrastructure to work with less energy, not more.

The focus of investment should be on localisation of food production, industry, education and other services.

Investment in renewables should be subsidised. We need to ramp up renewable energy so that it can take up the slack when fossil fuels decline. There needs to be rigorous analysis of the energy returned on energy invested for renewable energy technologies to ensure that they are effective. Analysis of the effectiveness of renewable energy using only money is distorted by current energy prices, in the future high energy prices are likely to be higher than today but the cost of energy intensive commodities like steel and concrete is likely to rise in parallel.

What are the key issues surrounding the development of Scotland's bulk electricity transmission and local distribution systems?

The grid is adapted to centralised production at a few locations and is poorly suited to distributed generation at many remote locations such as may be required by moves to large scale renewable energy.

Investment in the electrical grid has traditionally been demand led, that is new demand has stimulated investment in infrastructure. Trends in decline in domestic production of coal, oil and gas and the decline of nuclear power plants indicate that electricity use in 2025 will be significantly less than today. We will not be able to afford to import energy commodities in the necessary quantities and renewables have their limits. This decline in overall demand will give significant spare capacity in electricity distribution networks (spare capacity but not spare electricity).

Energy Demand

What will the impact of energy availability and price be on the demand for energy by commerce and industry in Scotland?

Prices will rise to a level that will cut demand unless rationing is implemented.

Scotland is sparsely populated when compared to much of the UK. Rises in fuel prices will make some businesses not viable, others will thrive. Tourism is a huge part of the Scots economy, and key to economic growth. Tourism is very dependent on cheap air travel and cars.

Oil demand from road haulage will decline as long distance transport for everyday commodities like food, ceases to be viable and local solutions are implemented.

The North Sea oil industry will boom for a while as oil prices rocket but by 2020 most of the production industry will be gone. The helicopters, boats and other support industry of North Sea oil are very energy intensive and this demand will fall.

Local food production will become more viable. Rises in the cost of fertilizer and pesticide will make organic food production more competitive. Holidaying in Scotland may become more popular for a while.

What are the likely trends in the domestic demand for energy for space heating and other purposes? What would need to be done to achieve major savings? What are the investment costs?

Initially people will use their timers more and use less hot water, and turn down thermostats. Domestic supply disconnections will increase as bills rise and economic problems accumulate.

There has been a trend towards smaller numbers of people per dwelling over the last 100 years. A movement towards larger households would provide large, quick and cheap savings in energy demand. There is still scope for simple measures like loft insulation and draught proofing. New build houses could be much better but the move to larger households would quickly remove demand for new housing. We will have to adapt what we have given the short time available to adapt.

Domestic car dependency means that cuts in diesel and petrol use will have significant societal impact.

Inevitable rises in the price of petrol and diesel (or rationing measures) will force people to use their cars less which will cause real distress to many people who have come to depend on their cars for work and leisure.

Big savings in domestic car use can be achieved by [26]:

- Not travelling (using local services or staying at home)
- Increased use of public transport, walking or cycling
- Compressed working week (eg. three day week)
- Limit petrol station opening
- Speed reduction (eg. 50mph)
- Enforcement of existing speed limits
- Partial Driving Bans (odd/even number plate days)
- Fuel rationing

What are the likely trends in the demand for energy for transport in Scotland? What is the likely time-scale and scope for substituting other power sources for fossil fuels? What are the likely investment costs?

Demand for transport fuel will decline as oil prices rise or if rationing is implemented. Much of the reduction in demand will not be substituted. There will simply be less transport. People will travel less and will have to move house, move job, move school and change their leisure activities as a matter of necessity. There will be more walking and cycling. Local shops will reappear and big out-of-town superstores will close. Big employers will be close to public transport routes.

Alternatives to diesel and petrol on the necessary scale do not exist. Hydrogen, being an energy carrier, demands more energy in a time of declining energy availability. Spare natural gas does not exist to supply hydrogen to aid the transition. Biofuels may be a useful way of using waste materials. Biofuels like biodiesel from waste cooking oil and sawmill waste may have important roles but will not supply the 28 million cars operating in the UK [27]. Agriculture will struggle to maintain current food production with the decline of natural gas-based fertilizers. In this scenario the additional demands of biofuel production are unlikely to be met.

What renewable energy does become available will be most valuable in offsetting decline in natural gas used for electricity generation. Renewable energy will not be available for mass market hydrogen production.

Investment should be focused on rebuilding our infrastructure to work with less transport and less energy, not on alternative energy sources for private cars.

The focus of investment should be on localisation of food production, industry, education and other services.

Subsidy of road transport exists in many ways such as space demands in cities, tolerance of casualties, noise and pollution. Making users of cars and truck accountable for their existing burdens would be a step forward.

Simply replacing car use with public transport is not practical in many cases. For example many people who live out in the countryside and commute to school and work will find bus services too sparse or infrequent to meet their needs. Many businesses and shops are located in out-of-town campus developments that are not compatible with public transport.

Air travel will decline as fuel costs rise in the coming years. The replacement of air travel with national high speed rail is not worth the cost, especially as high speed rail consumes more energy per passenger or tonne km than traditional rail [28]. There will be more pressing and more local transport problems where the investment could be better spent. As oil supplies decline, and therefore car travel

becomes less available, speed of transport will become less important in general. Rail travel will no longer have to compete with air travel and oil-powered cars.

Large energy savings can be achieved by switching much more traffic to rail. It has been estimated that long distance rail freight using fully loaded trains can achieve energy savings of up to 5 times that of trucking [29]. Eventually, rail travel will no longer have to compete with air travel and oil-powered cars, and therefore optimum operating speeds for both passenger and freight services should be adopted so as to minimise energy consumption and track wear while maximising the number of train paths. Major route upgrades together with re-opening of some rail routes previously closed will be required. We need to invest in low energy infrastructure while we still have spare resources to do it, such as upgrading main line railways to be effective replacements for trucks.

Existing canals should be made serviceable once again and consideration be given to providing new canals between major centres where topography is suitable. Much greater use of coastal barges should be made for transporting freight wherever possible. Shipping is extremely energy efficient compared with road and air. [30]

Ferry terminals will need to be re-integrated with the rail network. Currently the emphasis is on 'how to drive to the ferry terminal' rather than 'how to approach it via an integrated public transport system'. An example of a new, car-dependent, ferry terminal is Cairnryan which ferries to Northern Ireland, increasingly use moving from the traditional terminal of Stranraer (which still has a rail connection). The decline in oil availability will lead to more foot passengers using this key route between Scotland and Northern Island as 'low cost flights' will become a thing of the past.

Environmental and Social Issues

What are the environmental concerns that need to be taken into account, in terms of the impact on ecological and other natural resources, as well as waste management and impacts on the landscape?

Coal is likely to be cheaper and more easily available than gas and oil in the future, despite the need to import much of our coal needs. Globally, large coal reserves exist and it can be easily transported by ship. Despite the implications for global warming, we anticipate renewed enthusiasm for coal, for electricity production and perhaps domestic (in the home) use.

Can the objectives of environment improvement and economic growth both be met without a major increase in energy costs? What steps should be taken to enable an informed debate on the issue?

The impending peak in global oil supplies will stop economic growth. Declining gas supplies will add to the problems. Even keeping mains electricity on will be very challenging.

An informed debate on energy would be helped by analysis that is independent of corporate interests, particularly oil and car companies.

The media could be better informed. Too often issues of energy supply are given to economics correspondents who are not experts in resource issues.

What are the social values and consequences of energy generation and distribution on employment opportunities, health, and energy affordability?

The increasing cost of cars will make motoring an increasingly exclusive activity. This will be economically and socially disruptive and may cause social unrest.

The introduction of inverted or 'Lifeline' energy tariffs needs to be considered whereby the first block of units of consumption (typically 50 – 60% of average household consumption) is charged at the lowest price with each additional block being charged at progressively higher prices [31]. In this way excessive use of energy is discouraged but lower users (often people living alone or on low incomes) are not relatively penalized. Currently tariffs work in exactly the opposite direction in that the standing

charges disproportionately impact low users and heavy users are even offered volume discounts. This type of solution may sound radical but both UK and the world are entering a whole new era in energy availability and it will certainly be necessary to consider options which have been relatively unthinkable in the past. Doing nothing is certainly not an option.

Many important services like schools, hospitals and shops have been centralised. Local facilities have closed and dispersed people have to drive to obtain essential services. To replace lost local infrastructure will take time and resources. We are short of time and will in future be short of resources.

Localisation of economies could help to rebuild community spirit and social cohesion after years of division and isolation integral to car-based lifestyles.

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Max Oakes, MIMechE, MIGasE, CEng, BEng (Hons)

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[1] Several big investment banks have recently released reports of the impending peak in global oil production. The first was Deutsche Bank in December 2004, “Energy prospects after the petroleum age” :
http://www.dbresearch.de/PROD/DBR_INTERNET_DE-PROD/PROD0000000000181487.PDF

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http://news.bbc.co.uk/2/hi/business/4399537.stm

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Mellon Global Investments issued a report in February 2005, “Oil Price outlook: OVER A BARREL, Complacency and the Threat of Diminishing Oil Reserves” :
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In April, the Bank of Montreal issued a report predicting that Saudi Arabia's - and the world's - biggest oilfield, Gharwar, is in irreversible decline:
http://english.aljazeera.net/NR/exeres/08B97BCF-7BE6-4F1D-A846-7ACB9B0F8894.htm

Matthew Simmons, Chairman of Simmons and Co International, has published many articles on Peak Oil, especially on Saudi Arabian oil production eg.:
http://www.worldoil.com/Magazine/MAGAZINE_DETAIL.asp?ART_ID=2486&MONTH_YEAR=Feb-2005
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[2] In his article "OIL DEPLETION? It's All In The Assumptions", Ronald R. Cooke reviews the assumptions made by Cambridge Energy Research Associates (CERA) in their recent optimistic report, "Worldwide Liquids Capacity Outlook To 2010— Tight Supply Or Excess Of Riches". In the ‘Reality Check’ section of his article, Cooke summarizes the most recent opinions of various leading players, including ChevronTexaco, ExxonMobil, Shell and Saudi Aramco, the Saudi Arabian state oil company:
http://www.financialsense.com/editorials/cooke/2005/0728.html

In the article "The Energy Crunch to Come", Michael Klare takes a slightly different angle, the reporting of diminishing reserves by the so-called ‘oil majors’ (major oil companies):
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The global peak of all hydrocarbons (oil plus gas) is likely to be in about 10 or so years. (Bentley, June 2004): http://www.hubbertpeak.com/Bentley/
Jean Laherrere suggests global natural gas production peaking about 2030: http://www.peakoil.net/JL/JeanL.html

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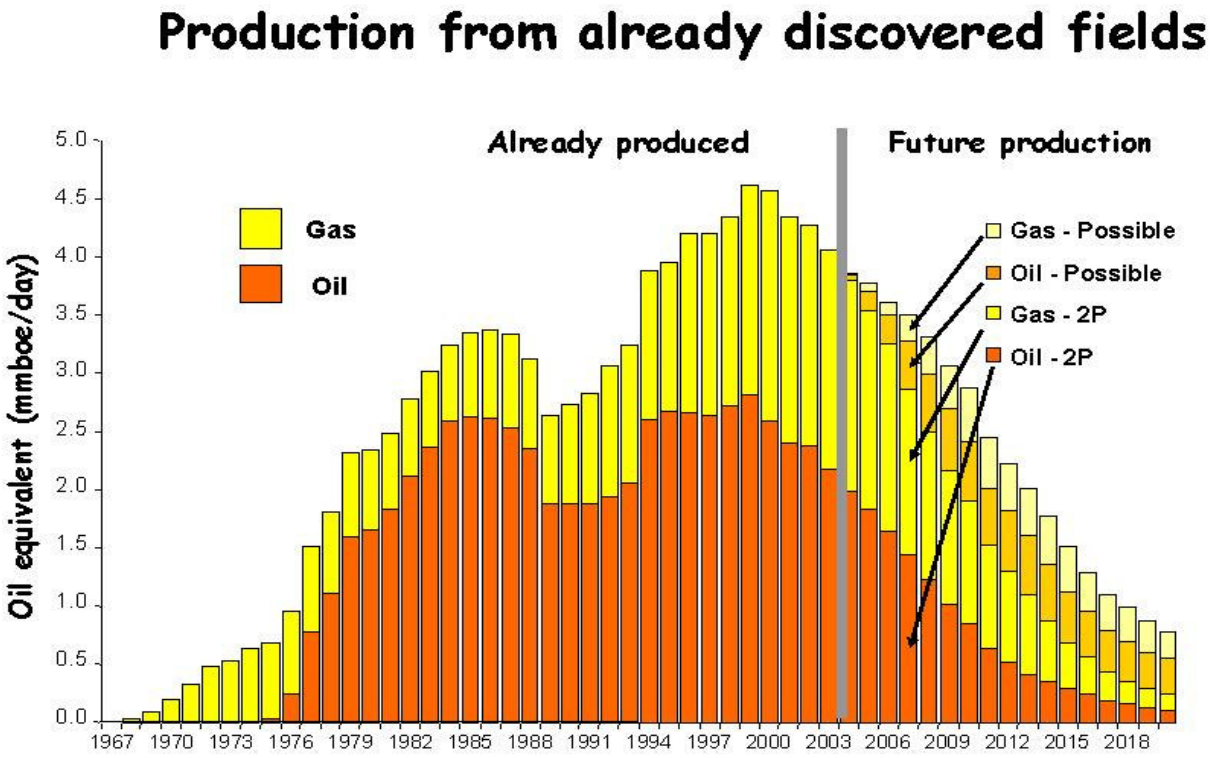

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