How to accelerate the UK's contribution to the global energy revolution, and keep the lights on

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A report by the Sainsbury Management Fellows' Society

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June 2009

Key facts

- UK carbon emissions fell by 13% between 1990 and 2000, but this rate of decline has since almost halved

- In 2000 the UK was a net energy exporter, and ranked 7th in the list of global oil, gas and coal producing countries. Today it is a net importer of fossil fuels

- In May 2008, hundreds of thousands of people in the UK were hit by electricity blackouts when seven power stations shut down

- On 20th February 2009, Britain hit a new low with just four days-worth of gas in storage

- Global energy infrastructure investment required by 2030 to keep pace with demand growth is estimated at $25 trillion

- This figure could increase to $45 trillion if we are to meet rising global demand whilst addressing climate change needs

- UK trade and investment asserts that the UK is the world's second biggest investment location for renewable energy firms after the US, yet public market new investment in UK sustainable energy sector companies was just 12% of that in French companies and 7% of that in German companies in 2008

- Although the UK is one of the windiest countries in Europe, new wind farm construction in 2008 proceeded at half the rate of that in Germany and Spain, where over twelve times current UK capacity is now installed

- In March 2009, the world's biggest investor in wind power announced a £300M reduction in its investment plans for the UK. Shell and BP have also shelved plans for renewable power investments in the UK

Summary

Energy supply in the UK is about to enter a period of crisis. With North Sea oil and gas production declining rapidly, many of our ageing nuclear power stations due for retirement, investment in renewables virtually stalled and carbon emissions from power generation and transport rising, solutions are urgently needed. Like the global financial and economic turmoil, the approaching energy crisis is global in nature, but the UK is acutely exposed for historical and structural reasons. The coming energy transition will be as demanding as any in our history, and will affect not only today's suppliers and users of energy, but also the lifestyles and environment of many future generations. The divergent and in some cases conflicting interests of this broad range of stakeholders must be reconciled.

UK government must put in place policies to address this crisis as a matter of urgency:

- **A credible UK energy strategy must be developed that goes beyond climate change.** It must include realistic, explicit, measurable, medium term aims that span climate change, energy security, energy cost, efficient and sustainable use of resources, and the UK's wider impact on these global energy challenges. There must be clear and auditable links between the overall aims of policy, the pace of change in infrastructure, technology and behavior, and the performance of policy measures put in place.

- **Government must take a leading role in major infrastructure projects.** New infrastructure will be required to deliver our future energy supply, and is an essential enabler for many of the new technologies that will be needed. Barriers to investment must be removed, and consistent policy incentives and penalties maintained to support private sector investments in clean, reliable and sustainable energy.

- **Policy must provide a clear stimulus to consumers**, so that choices and behaviours work in concert with changes in the way energy is supplied. Over time, this can create a smarter, more efficient and more sustainable market demand for energy even as quality of life continues to improve.

UK government must provide strong leadership if we are to meet this challenge. By drawing on our engineering, process industries and life science capabilities, UK industry can quickly develop, select and deploy the right mix of energy technologies for the UK's long term energy needs, and make a major contribution to global energy sustainability. In doing so, the UK economy will benefit from becoming a global leader in the supply of sustainable energy technologies and management systems. However, such investment and innovation requires a stable and coherent policy and fiscal framework, and which aligns the efforts of government, industry and consumers towards a common set of clearly defined aims.

Historic context

> "*The world faces the daunting combination of surging energy demand, rising greenhouse gas emissions and tightening resources. A global energy technology revolution is both necessary and achievable; but it will be a tough challenge*".
>
> Nobuo Tanaka, Executive Director of the IEA – 2008 (1)

Wind the clock back just a few years, and such a statement might have seemed alarmist and – from a UK perspective – irrelevant. In 2000 the UK was a net energy exporter, and ranked 7th in the list of global oil, gas and coal producing countries (2). Compared to 1990 it had reduced total greenhouse gas (GHG) emissions by 13%, including 22% savings in the power sector and broad-based savings across many other sectors of its economy (3) (4). The UK's energy transmission and storage infrastructure had come through 70 years since the national grid was created in the 1930s without major disruption. Energy was cheap (and getting cheaper), and energy companies were profitable. Economic efficiency was also improving, thanks to our post-industrial service economy, and the UK was using less energy to generate each pound of GDP than ever. This 'energy intensity' had fallen in real terms to less than 60% of the levels seen before the oil crises of the 1970s (5).

Like those energy supply shocks, events unfolding between 2000 and the summer of 2008, when Nobuo Tanaka made his address to G8 leaders, demonstrate just how rapidly things can change. The UK is today a net importer of oil and gas, and its GHG emissions savings have slowed dramatically since 2000 (2) (3) (6). The National Grid's dependency on imported gas has risen even as the secure supply of gas into Europe has been cast into doubt (7). Without a corresponding rise in gas storage, we are now left with just a few weeks of supply cover, and this reserve level has at times has become critical. On 20 February 2009, Britain hit a new low with just four days-worth of gas in storage (8). And as our ageing fleet of nuclear power facilities approaches retirement, our spare power generation capacity in the UK is projected to fall to perilously low levels. In May 2008, a National Grid disruption resulted in blackouts in Cleveland, Cheshire, Lincolnshire and London affecting hundreds of thousands of people when seven power stations shut down. This incident was reported in the Times newspaper as "an unprecedented sign of the fragility of Britain's power infrastructure" (9).

However, unlike the oil shocks, much of what has transpired did not happen without warning. In most cases these changes represented a continuation of historic trends and the playing out of policy decisions made in the UK and elsewhere over preceding years. The decline in output of the North Sea oil fields, the decommissioning schedule of nuclear power stations alongside the stalling of new-build, and the end of the very substantial one-off carbon savings from our 'dash for gas' in power generation, all were structural changes known and anticipated well in advance.

Over the course of the next 40 years, another set of predictable changes will play out. Ongoing carbon emissions, together with a range of other factors, will continue to warm the planet causing disruptive climate change and increasingly severe weather events. Global supplies of

'conventional' oil will plateau and decline, as new forms of 'unconventional' fossil fuels are developed to replace them. Global population will approach and perhaps exceed 10 billion. The world's developing economies will grow, along with their demand for energy in all its forms. And a large proportion of the infrastructure that will supply energy to developing and developed countries in 2050 will be put in place.

As Mr Tanaka says, a revolution is required to create the necessary energy technologies and infrastructure to meet the combined challenges of climate change, energy security, rising demand and resource depletion, both globally and in the UK. Recognising the climate change challenge, the UK has set itself a demanding target to reduce carbon emissions by 80% by 2050, in addition to the targets set for 2012 and 2020 by Kyoto and the EU's Climate Change and Energy package (10) (11). However, the UK also needs a sustainable energy supply that is secure and viable. It must keep the lights on at reasonable cost, meeting energy demand not only in 2050, but in every year before and after. This challenge will become increasingly difficult as our power generating base becomes more dependent on imported gas, and intermittent wind power replaces more predictable, though more polluting coal.

A credible UK energy strategy

The UK can create a domestic energy supply that meets these challenges. But to do so, a credible energy strategy is required that sets clearly defined and measurable aims, a coherent and achievable path, and auditable links between the impact of current policies and the ultimate objectives.

[Box out 1 – Key questions for a credible strategy]

The EU's Climate Change and Energy package is a good example of a policy framework based on this type of approach. Of course, there is no guarantee that the Climate Change and Energy package will deliver on its overall aims. But by 2020, the policy will have unambiguously succeeded or failed, and by 2010 the plans and measures in place will give an indication of whether the EU is on track to deliver.

UK energy strategy provides no such clarity. In 2007, following its Energy Review, the Department of Trade and Industry published its international and domestic strategy in a white paper (12). This strategy is intended to create the right conditions for investment in energy infrastructure, and to encourage the development of the new technologies that will play a part in our future, more sustainable energy supplies. It reiterates four objectives set out in the 2003 Energy white paper (13):

- To put ourselves on a path to cut the UK's carbon dioxide emissions by some 60% by about 2050, with real progress by 2020 (in 2008 this target was increased to 80% in line with the recommendations of the Climate Change Committee)
- To maintain the reliability of energy supplies;

- To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
- To ensure that every home is adequately and affordably heated.

These objectives do not provide the criteria for success or failure. Only one of these aims, the GHG emission reduction target, is quantified. The need to play a proactive role in the decarbonising of power in developing economies through carbon trading, global policy agreement, technology transfer, and direct investment is also acknowledged, but there is little indication of what the UK plans to achieve, and what would constitute success.

The intended 'destination' energy mix of the government's energy strategy is unclear. For example, although nuclear power receives some qualified support in the DTI strategy paper, there is no indication of a minimum or maximum share of the power generating mix that nuclear, coal, gas or renewables must provide by 2050, in order to meet energy security and climate change targets.

Neither does the government's strategy set out a clear roadmap for the delivery of a wider set of energy goals, as opposed to the climate change targets specified in the recently adopted interim carbon budgets (4). At the least, our energy roadmap should identify intended rates of new power generation build and decommissioning, the required development of spare capacity and storage levels across all energy sectors, and diversification of supply sources for imported energy.

Yet the greatest gap between the proposed strategy and the government's approach is in the definition and delivery of the means: the specific elements of infrastructure and other capital investments required, technological challenges that must be overcome and changes in consumer behavior that are needed. The proposed strategy fails to draw a clear distinction between the roles of government, industry and the consumer in achieving its overall aims. The default approach in UK energy policy, as in industrial policy, has been to set directional incentives and leave it to the market to establish the means. This approach can deliver incremental change but not the energy technology revolution that is required, a shortcoming acknowledged by Peter Mandelson, quoted in the FT in March 2009:

> *"We have not set major infrastructure objectives and then organized our industry and supply chain to deliver them as has been done in France. We are quite good at putting the regulatory system in place but we have always assumed the supply side would take care of itself".*

Until an 'Energy Audit Committee' is created with a remit that holds government to account, this ongoing failure to define and follow a clear path for UK energy provision will continue to go unnoticed. This is the underlying reason that the UK's energy and climate change policy is failing, and until this gap is addressed our carbon reduction targets will not be met, and our energy security will continue to deteriorate. Current policy is rightly focused on the twin challenges of climate change and energy security, but the approach must change if it is to succeed - 'Just wishing don't make it so'.

Government must lead the infrastructure challenge

Global energy infrastructure encompasses a wide range of large scale assets employed in primary energy production, storage, conversion, distribution, and end use for each energy sector. As the primary energy mix, sources, conversion technologies and end use patterns change, existing infrastructure becomes obsolete and new investments are required. In addition to the ongoing infrastructure challenges of developing new oil and gas finds whilst extending the life of existing fields, new infrastructure is required to bring alternative sources of primary energy to market, liquefy and transport natural gas, increase buffer stocks, integrate renewable power generating systems, and store carbon dioxide emissions. The capital cost of renewing and developing existing global energy infrastructure alone is truly colossal. In 2008, the IEA estimated that the global infrastructure bill to keep pace with rising energy demand will run to $26 trillion by 2030 (14), just to keep the lights on. Meeting rising energy demand, whilst at the same time moving to climate-friendly generation, could cost as much as $45 trillion within the same period according to some estimates (15) .

Much of this investment needs to be made by business in response to market and policy signals, but the UK's performance at attracting new finance into the sector is poor. Public market new investment in UK sustainable energy sector companies was just 12% of that in French companies and 7% of that in German companies in 2008 (16). Although the UK is one of the windiest countries in Europe, new wind farm construction in 2008 proceeded at half the rate of that in Germany and Spain, where over twelve times current UK capacity is now installed (17). In 2008, Shell decided to pull out of the London Array wind farm to focus on developing its US wind assets. In March 2009 Iberdrola Renewables, the world's biggest investor in wind power, announced a £300M reduction in its investment plans for the UK (18).

In some cases government must incentivise or lead infrastructure investment. For the one off big-ticket items, like the DC power grid that is required for efficient off-shore wind power from the North Sea (19), the scale of investment and risks are often greater than most firms are prepared to bear – although if government invests directly or guarantees a revenue stream, then private funding becomes more tenable. Not only does government generally have deeper pockets than business for projects of this scale and ambition, it does not bear the same burden of policy and regulatory risk that has thwarted many promising new ventures in the UK and contributed to the flight of renewable power investments to the US and Europe.

Some degree of government regulation of common infrastructure can improve market efficiency to the benefit of business and end-user customers, especially for infrastructure that would otherwise form a natural monopoly. In addition, such investment is essential to manage supply risks. Secure energy supplies require investment in spare storage, generation and distribution capacity, but businesses will not willingly put capital into assets that spend most of their life unused unless an efficient and reliable market mechanism exists to reward this investment. California's rolling blackouts in 2001, and the more widespread power disruptions in across

eastern US states in 2006 were attributed to market inefficiencies that crept in following deregulation of the US generation and distribution from the late 1990s (20).

Government leadership can also direct common infrastructure technology or standards that allow for rapid improvements in service and cost. The UK's 1926 Electricity Act created the necessary regulation and standards (including voltage and frequency) for national electricity distribution. Prior to 1926 UK electricity supply consisted of a patchwork of authorities servicing restricted areas, and the Act allowed these fragmented systems to be integrated into a common National Grid by 1936. Similar standards will be required before technologies such as distributed micro-power generation, biogas distribution and carbon capture infrastructure can be deployed and flourish at a national level.

Demand-side management is critical

Whilst much of the debate so far has focused on energy supply, energy sustainability and security is as much about energy demand since the overall aim is to continue to marry energy supply and demand without interruption and without causing environmental damage.

Consumer behavior is critically important since this can dramatically alter the demand for energy, for the simple reason that there is no absolute consumer requirement for energy. Energy demand is described by economists as 'derived demand'. That is to say, people and businesses consume energy in various forms only to meet their needs for food, comfort, mobility, leisure activities and so on. By way of example, the energy required for a meeting between business parties or family members depends on the selected mode of transport, the choice of vehicle, the type of fuel, the style of driving and, communications technology permitting, whether any travel is required at all.

Such choices on aggregate result in the derived demand for energy, and can be influenced in a number of ways, price being the most obvious. Since the 1980s, high fuel taxes in the EU have set pump prices far above those in the US. As a consequence, EU consumers demand more efficient vehicles, move closer to their place of work and use public transport more frequently than their American counterparts.

Social norms and peer pressure also influence behavior, especially when that behaviour is visible. Part of the reason that towns such as Cambridge, York and more recently London have far more cyclists than average in the UK is that once a 'critical mass' of journeys are made by bike this is no longer seen as unusual. More people become open to the idea of cycling as an alternative form of transport, and new habits are formed. Peer pressure has played a key role in the popularity of innovative new cars such as Toyota's Prius hybrid, and in the spread of solar and wind micro-renewables in Germany where more than a million households now generate their own power.

Consumer choices can also be influenced through regulation. This can be done indirectly through the control of information communicated to buyers of energy-hungry products such as of fridges,

cars and houses. Regulation can also constrain consumer choice, for example by banning the sale of inefficient products such as incandescent light bulbs, or restricting traffic lane use according to vehicle type or occupancy.

In practice, several of these influences must be applied in concert. Before the phase-out of leaded petrol in the UK in 2000, a decade of near-universal availability, new vehicle compatibility, public health communications and a significant price differential were required to lay the foundations for this mandatory change.

Not only does consumer behaviour offer many opportunities to influence overall energy demand, it can avoid much of the cost of new technology development and infrastructure. For this reason, behavioral change can be one of the most cost-effective means to achieving energy policy aims.

Grounds for optimism

The challenges for global energy supply in the near future are surmountable. Although the UK is acutely exposed to some of these challenges, it is also remarkably well endowed with the resources to overcome them. The UK still has reserves of oil, gas and coal, some of the best wind, wave and tidal energy resources in the world, and rising agricultural and biomass surpluses that will all play a part in our future energy mix. The UK’s historic energy, offshore and process engineering capabilities can provide the basis for the infrastructure projects, technology development and innovations that will be needed. New companies such as Pelamis and Seagen are proving today that new, commercially viable renewable energy technologies can be developed and brought to market by UK industry.

With a clear vision and effective strategy, we can make the most of this potential. We can meet our future energy needs in a way that is clean, secure, viable and sustainable, and in doing so the UK can play a leading role in the coming global energy technology revolution.

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[Box out 1 – Key questions for a credible strategy]

	Key questions	**EU Climate Change and Energy package example**
Aims	• What are the overall aims of policy? • What are the characteristics of the desired future state of our energy supply and demand? This requires objective statements that define targets for energy demand, security, sustainability, emissions and cost for each sector of energy use in the UK (For example, what is the acceptable level of risk of a major blackout)	The overall aims of the policy are explicit, objective and measurable: By 2020, to cut greenhouse gas emissions by 20%, to establish a 20% share for renewable energy, and to improve energy efficiency by 20%.
Destination	• What might the UK energy supply & demand mix look like, when these aims are met? • What are the constraints for each high supply sector so that overall supply and demand are consistent with the defined aims? (For example - In the power sector, what are the upper and lower bounds for gas, nuclear, wind and so on)	The destination is defined with sub-targets in different sectors, and with differentiated targets for member states.
Roadmap	• How will energy supply and demand change from today's mix to that intended in future? • What milestones must be passed along the way? What are the unknowns? (For example - In transport, over what period and at what rate should grid power replace liquid fuels between now and 2050)	Roadmaps are deliberately devolved to Member States, but the package includes mandatory requirements for countries to define and commit to an intended path in National Action Plans by 2010. The package also includes 'indicative trajectories' which, though not mandatory, set expectations for the pace of change.
Means	• What new infrastructure, capital investments, technologies and behaviours are required to produce the requisite changes in supply and demand, and take us down the intended path. (For example – A carbon capture gas network and a North Sea DC power grid may both act as essential enablers for private sector investment in clear power generation)	The means are explicit, with defined roles carved out for market-based capital investments to reduce greenhouse gas emissions, increased used of renewable energy in power and transport, new vehicle efficiency standards, transport fuel emissions savings, and carbon capture & storage technologies.
Policy	• What part will be played by the government, by private enterprise, and by the consumers of energy? • Where should policy incentives & penalties be focused to encourage the market provides these means, andwhere should government provide the means itself? (For example – Current policy measures that define emissions trading and obligations, R&D investments, and consumer incentives to cut energy use.	Specific policy instruments are set out to address each of these areas: An extended Emissions Trading System; The Renewable Energy Directive; The Fuel Quality Directive; and the Directive on Geological Storage of CO_2
Audit	• Are the policies in place achieving their intended results? • What are the leading indicators that change is taking place at the intended rate, and how is policy performing against these indicators? (For example – At what rate is private sector investment flowing into new energy infrastructure projects in each supply sector)	The package sets out a mandatory process for Member States to measure and report on progress.

The Sainsbury Management Fellows' Society

The Sainsbury Management Fellows' Society was set up to develop UK engineers as leaders in industry. The society believes that the combination of Chartered Engineering status and a top MBA degree are ideal professional qualifications to help influence, shape and lead UK industry.

The SMF award scheme is administered by the Royal Academy of Engineering. It provides a bursary to chartered engineers to study for a Masters degree in Business Administration (MBA) at internationally renowned business schools. Upon successful completion of the MBA, the engineers become a member of the SMF Society, which provides a range of benefits including networking, courses, mentoring, plus careers support.

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