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IS UK ENERGY POLICY DRIVING ENERGY INNOVATION – OR STIFLING IT?

Candida J Whitmill
Director of Policy, mc^2 Energizing Business
Email: candida@mc2business.co.uk

ABSTRACT
Alarmed by what Lord Stern famously described as "the biggest market failure in history", the European Commission has been prolific in producing policies to force the reduction of greenhouse gas emissions, in particular carbon. The EU "20-20-20" Directive demands that by 2020, 20 per cent of energy comes from renewable sources, emissions are 20 per cent lower (compared with 1990 levels) and energy efficiency reduces demand by 20 per cent. The UK's individual target is 15 per cent renewable energy, which means that the fraction of electricity supplied by renewables must more than triple to 35 per cent. Since the general election in 2010 the Coalition has continued with plans to decarbonise the economy, beginning with the largest carbon emitter, energy generation. This paper argues that the Coalition's emphasis on rewarding increases in capacity without a corresponding improvement in performance and a reduction in costs is at the expense of technological innovation, R&D and a skilled workforce.

1. INTRODUCTION

New Labour's Energy White Paper of 2007, *Meeting the Energy Challenge* [1] proved to be a far more pragmatic approach to energy security under environmental constraints than its 2003 predecessor [2]. An honest appraisal reflected the difficulties in predicting both the demand for energy and the international political landscape in 2050. In the short term, it acknowledged the need for 30-35GW of new electricity generation to replace old and retiring plant, two thirds of that to be built by 2020. Significantly, the White Paper reversed previous policy on nuclear in recognition of its contribution to carbon targets and security of supply. Nuclear was back on the agenda, albeit with the caveat of no public subsidy. Less coherent was the legacy of policy instruments that would add "green taxes" to consumers' utility bills. Feed-in tariffs, which pay consumers to install renewable technologies such as solar power, came later; they were dismissed due to a lack of international evidence of their effectiveness. Emphasis was placed on the need for innovation in new low carbon technologies, while it was also recognised that the R&D framework required to fulfil this low carbon challenge was not in place. The failure of the market to deliver R&D, following the

closure of the Central Electricity Generating Board (CEGB) [3] would be addressed, although a rather linear approach to innovation was suggested [4]. Overall, the Paper sought a market-based approach to non-market objectives (environmental targets), but Helm described it as "a modest further step in the attempt to construct an energy framework which marries up the liberalised market and competition regime inherited from the 1990s, with a set of public aims and targets which the market would not on its own deliver" [5].

Within 18 months the Conservatives, still in opposition, accused Labour of failing to "live up to its own rhetoric" [6] by not investing sufficiently in renewable energy and household energy efficiency. Conservative policy enthused about carbon capture and storage (CCS), combined heat and power, biogas; a collection of ideas rather than a coherent strategy. As so often happens in opposition, the party gave an indication neither of costs, nor of the engineering challenges to be overcome. Following the May 2012 General Election and the formation of the Conservative-Liberal Democrat Coalition, the realities of achieving legally-binding, over-ambitious low carbon targets have resulted in methods rather more interventionist than the traditional Conservative free-market approach. Low carbon energy is however, just one of three fundamental objectives, the other two being affordability and security of supply [7].

To move away from fossil fuels will not be easy. In 2011 renewables produced 9.5 per cent of UK electricity; in the final quarter of that year, 4.2 per cent of UK electricity came from wind [8]. The UK still depends on coal and gas for 70 per cent of its electricity (nuclear produces 19 per cent) [9]. Even without climate change-induced carbon targets, arguments in favour of reducing fossil fuel dependency remain. The geopolitical sensitivity of the major fossil fuel producing areas remains a concern, particularly around oil and increasingly around gas too, as the UK's indigenous North Sea reserves of both fuels move towards depletion. From a position of self-sufficiency, the UK will be importing 80 per cent of its gas requirements by 2020. Building extensive gas plant now will lock the UK into expensive, volatile gas prices with variable security of supply, and subject to intense competition from the emerging economies.

Of course, innovation in oil extraction techniques has opened up the availability of shale gas, which has had a considerable impact in the United States in a remarkably short timescale; in less than 20 years production rose from practically zero to 20 per cent of domestic supply. Domestic gas prices have dropped significantly. However, in May 2012 a Downing Street seminar attended by Shell, Centrica and other interested parties drew up a more pessimistic outlook for similar benefits in the UK [10]. Such a domestic resource has yet to be proven and many European countries now face strong environmental objections to "fracking", a technique that requires vast quantities of water and chemicals. Jacoby et al [11] caution against using shale gas as a "bridge" to a low-carbon future, not only because of the uncertainties of such a nascent industry, but also because such a course may delay the development of CCS technology that will eventually have to be applied not only to coal, but to gas too. Gas, although cleaner than coal, still emits 0.5kg of CO_2 per kWh, which will derail any attempt to comply with carbon targets. Any "dash for gas" could result in new gas plant being built in areas geographically unsuited to the retrospective fitting of CCS technology.

Coal, although it emits mass volumes of carbon, is plentiful, accessible and cheap, and thus has increased its global market share. Coal provides an average 47 per cent of the UK's electricity. Due either to old age or to compliance with the EU Large Combustion Plants Directive, over a third of the UK's coal power stations must close at the end of 2015 [12]. New coal plant is now banned in the UK unless CCS is fitted; a technology yet to be proven on a commercial scale and with unknown costs. The early closure of fossil-fuelled plant before creating the capacity to replace it is worrying a number of energy experts. Professor James Lovelock suggests we should be working for a transitional rather than a revolutionary move to alternative low-carbon energy sources, and warns that "we cannot turn off our energy-intensive, fossil fuel-powered civilisation without crashing; we need the soft landing of a powered descent" [13].

Currently only nuclear power produces baseload, low carbon electricity. Although nuclear power is now once again part of the UK's energy policy, the damage to the Fukushima nuclear plant following the March 2011 earthquake and tsunami in Japan left the world questioning its commitment to nuclear. The decision by German Chancellor Angela Merkel to close Germany's nuclear power stations prematurely has had such an impact on the balance sheets of RWE Npower and E.ON that the two companies have abandoned joint plans for new build nuclear at Wylfa in Anglesey and Oldbury in Gloucestershire. A Spanish/French consortium at Sellafield has shelved plans until 2015 at the earliest, leaving just EDF, which is owned by the French government, progressing with a planning application for two reactors at Hinkley Point in Somerset. Confidence to proceed with this £15 billion project will depend on the outcome of the Government's Electricity Market Reform, to which we will return later.

By contrast with nuclear power, EU legislation ensures that renewable energy technologies are a compulsory component of the UK energy mix. However, owing to their intermittent nature, renewables cannot provide baseload power. The wind often fails to blow and the sun does not shine at night, particularly during northern Europe's long winter evenings, when energy is most required. Conversely, wind can supply power when there is no demand for it, in which case turbines have to be switched off to prevent overloading the National Grid. In 2011 alone, compensation paid to wind power providers for such periods of inactivity cost consumers £25m.

Part of the problem is that the UK's National Grid infrastructure is inadequate to cope with both the intermittent nature of renewables and the fact that they are located far from centres of demand. Unlike its European neighbours, Britain is an island, without the advantage of being able to balance out peaks and troughs by trading across borders with contiguous countries. The mooted Europe-wide "Supergrid" is decades away in engineering terms, let alone in terms of political consensus. It would mean a Europe-wide energy policy to which Member States would have to sign up with the faith they showed when joining the Euro. Until economically viable, large-scale storage of electricity becomes feasible, the large-scale deployment of renewables in the UK is questionable.

Ofgem, Britain's electricity and gas regulator, predicts that to hit the UK's renewables target could cost in the region of £200bn [14]. The Department of Energy and Climate Change (DECC) confirms that £110bn [15] of that will be electricity

generation and transmission costs. Consumers' willingness to pay for low carbon on this scale has yet to be tested. Claims that bills will be cheaper by 2020, endorsed by the former Secretary of State for Energy, Chris Huhne, before he stepped down in February 2012, are unlikely to hold true. As the UK Committee on Climate Change concedes, "customers value electricity but they care less whether the electricity is generated from a wind turbine or gas turbine" [16]; the end product is indistinguishable. Price, and in turn affordability, has a more important role. The European Commission concedes that electricity in Europe is already 21 per cent more expensive than in the US and 197 per cent more than in China [17]. Billions of pounds of consumer-funded subsidies have contributed to nearly five million households in fuel poverty in the UK [18]. Industry estimates that green policies already account for 21 per cent of its energy bills. Further increases could force large commercial energy users to relocate some or all of their operations overseas, where less severe carbon measures allow them to remain competitive.

However, economists point out that we have enjoyed an era of plentiful supply of cheap energy, where externalities for environmental costs have been ignored, not surprisingly, as "the market cares nothing for the environment; it cares for today's generation, not tomorrow's" [19]. If carbon targets are to be achieved, this has to change. As the Organisation for Economic Co-operation and Development (OECD) explains, if environmental impacts are not priced in, businesses will not gain any significant advantage from reducing such impacts [20]. The necessary investment for innovation will not be forthcoming. Some element of intervention is requisite to level the playing field if carbon is to be the pivotal factor. Therefore, does the government have any choice other than to create an artificial market for renewable energy through a combination of regulation and market intervention?

2. NOTES ON THE HISTORY OF ENERGY MARKET INTERVENTION

There are precedents for a government-created market in the energy sector. In the 19th and early 20th centuries Britain ran on coal gas, which contained 50 per cent hydrogen and 9 per cent carbon monoxide. Although coal was plentiful, its use in this way was an expensive process. When ICI discovered a method of turning naphtha, a waste product derived from processing crude oil and marketed at £1 a ton, into a gas similar to coal gas, this new town gas was utilised. Natural gas, however, has combustion characteristics different from town gas and these made it unsuitable for distribution in the existing infrastructure. Thus the discovery of natural gas by state-owned BP in the North Sea in late 1965 produced a valuable product with no domestic market. At that point the government, through the then state-owned British Gas, underwrote the conversion of 40 million appliances for 13 million gas customers. The programme started in May 1967 and took 10 years to complete, at a cost of £563 million.

Energy remained nationalised for another 25 years, with policy driven by events rather than markets. In the 1950s the coal industry held a stranglehold over the UK's electricity supply. Constant threats of strikes and restriction of supply accelerated the decision to introduce civil nuclear power. In 1953 the decision was made to build the world's first commercial nuclear power station. Just three years later the Queen cut the ribbon at Calder Hall. However, by 1974 coal still produced 65 per cent of the

UK's electricity. Coal strikes, and a resulting three-day week, toppled Edward Heath's Conservative government. Eric Varley, the Energy Minister for the incoming administration, capitulated to the miners' demand for a 35 per cent pay rise [21].

It was the oil shocks of the 1970s that focused minds at the G7 summit in Venice in 1980. The leading Western economies plus Japan, which together represented more than 50 per cent of global GDP, took decisive action "to protect against future oil transgressions" [22]. The consensus was to break the existing link between economic growth and consumption of oil within a decade. A veto on construction of new oil-fired generating capacity would be supported by the introduction of new oil-saving investments in residential and commercial buildings, setting insulation standards, doubling coal production by 1990, and recognising the "vital contribution of nuclear power to a more secure energy supply". In the UK the strategy became known as Co-Co-Nuc: conservation, coal and nuclear. Transport would be addressed with more fuel-efficient vehicles and better public transport.

In 1982 the Conservatives decided to break up the state monopoly and leave energy to the market. At an international energy conference in Cambridge, Nigel Lawson, then Energy Secretary, said: "I do *not* see the government's task as being to try to plan the future shape of energy production and consumption... Our task is rather to set a framework which will ensure that the market operates in the energy sector... energy is a traded good" [23]. That statement prove to be the catalyst to privatisation of the energy industry, with the CEGB broken up into three new companies: Powergen, National Power and the National Grid Company. Following the European Commission's permission to allow the burning of gas for electricity, gas supply markets opened up during the 1990s. Although the result was lower CO_2 emissions, the "dash for gas" was effectively due to "the combined effect of the Conservative Party's agenda of economic liberalisation and its crusade against trade union power" [24].

Energy policy has gone from "command and control', to the free markets of plentiful supply, to the recent hybrid model. A plethora of market interventions and government vacillation have left investors and energy companies confused. Abstruse policy and failure to give the right market signals have left the energy sector, and thus the UK, in a precarious state.

3. INCENTIVES AND SUBSIDIES – TIME FOR A CHANGE?

To address the challenge, the Coalition government announced "the biggest reform of the energy market since privatisation" in May 2012. The Electricity Market Reform, or EMR Draft White Paper, finally recognises that "the market will not deliver" [25]. The core components are a feed-in tariff with Contracts for Difference and Capacity Agreements, the fine details of which are not yet forthcoming. It should give an opportunity to evaluate existing incentives and subsidies and their impact on driving innovation in low carbon technologies. There is a dilemma between subsidising the mass deployment of renewables to hit arbitrary carbon targets, and supporting innovation in technology with higher risk but greater long-term potential to perform. For example, two decades of support focused on wind power, a mature technology which has shown only modest improvements in efficiency, has done little to reduce energy bills or contribute to the UK's electricity supply. The OECD warns that governments are being

coerced into focusing on green policies that, without state support, would produce innovations with low rates of return. Not only could this deter investors, it could have a negative effect on technological progress and the overall economy.

To what extent is this due to the design of the subsidy programme? Currently, low carbon electricity subsidies in the UK, such as Renewables Obligation Certificates (ROCs) and feed-in tariffs, reward capacity, rather than performance. In the case of wind, there is no incentive to improve efficiency or reduce costs, thus ensuring the perpetuation of subsidies to prop up otherwise unviable technology.

Reducing costs is an important element of realising commercial viability. Research undertaken by Soderholm and Klaase concludes that, other things being equal, the higher the level of subsidy, the slower the pace of cost reductions for wind turbines [26]. This raises the question: should support be withdrawn for mature technologies that continue to fail to perform, either on price or efficiency? The aim should be to reduce subsidies for all technologies to zero over a determined timescale. At the time of writing, protracted negotiations between the UK government and the wind industry have concluded with a 10 per cent reduction in onshore wind subsidies, rather than the Treasury-recommended 25 per cent. We would argue that the subsidy structure needs a new direction that focuses on rewarding performance and reducing costs, rather than on extending capacity at any cost.

Direct intervention requires governments to have a global understanding of markets, if they are to avoid unintended consequences. When Germany introduced a car scrappage scheme to reduce the number of high-carbon emitting vehicles on the road, it did not foresee that, by not having an element of enforced destruction in its policy, the cars could be sold on to Africa and Central Asia, simply exporting rather than eliminating carbon emissions [27]. Likewise, hot-housing an otherwise unprofitable industry requires careful management. The rapid adoption of solar power has seen, in less than a decade, a cottage industry grow to a global $100bn business; in 2011 global capacity exceeded 65GW [28]. What has it achieved? Volker Beckers, chief executive of RWE, has confirmed that Germany now has 20GW of solar installations. That has cost consumers €40bn in subsidies, in return for a 0.7 per cent contribution to Germany's electricity supply [29].

In Japan, Germany, Spain and many other countries, results like this have precipitated the withdrawal or severe curtailment of the feed-in tariff. In the UK, tariffs and capacity levels were initially set too high, and the government's rapid downward adjustment only led to a myopic pursuit of installations to beat the deadline, at the cost of long-term development. China stepped in and flooded the market with cheap panels, which led to the collapse of solar manufacturing companies across Europe and the US, including, in 2008, Germany's Q-Cells, the world's largest solar cell manufacturer. As the OECD cautions, governments that do not undertake a rigorous evaluation of policies in the light of events risk failing. Intervention will prove both costly and ineffective. Interestingly, Germany and the US have reacted in different ways to the crisis in solar power, possibly because the US has a trade deficit with China, while Germany runs a trade surplus and has no wish for a trade war. Thus while the US has imposed import tariffs on Chinese solar products [30], Germany has sought to secure the high-tech part of the supply chain, leaving the relatively low-tech

assembly of panels to the Chinese. Germany exports complete solar production lines and is home to the world's largest inverter manufacturer, SMA, which continues to post impressive results under tough market conditions. Germany also supports Fraunhofer ISE, Europe's largest institute for solar research [31].

4. LESSONS OF R&D

Despite the absence of global consensus on how best to reduce greenhouse gas emissions, the development of low carbon technologies is a common denominator. To fast-track the process of innovation, there are suggestions that the "Climate Change Manhattan Project" [32], as first prescribed by Michaelson in 1998, could be resurrected. The idea was based on the US Manhattan Project and Apollo space programme paradigms. These projects were designed, funded and managed by federal agencies to achieve a specific technological solution for which the government was effectively the sole customer. By contrast, as Mowery et al [33] point out, with climate change massive private as well as public funding will be required, and for a heterogeneous group of technical solutions that must be cost-effective and be in operation for decades, with adoption across a diffuse set of stakeholders. Nonetheless, government procurement is a powerful catalyst for innovation. Post-war US military R&D in IT was the major factor behind three new industries; semiconductors, computer hardware and computer software.

Federal support for the development of the jet engine, again for military purposes, also spilled over into innovative gas turbines for electricity. Jenkins et al concur that the US government "has a long history of successfully driving innovative and price declines in emerging technologies by acting as a demanding customer to spur the early commercialisation, large-scale deployment and steady improvement of cutting-edge technology" [34]. The UK government spends £220bn on goods and services; perhaps much more could be done to support an early market for innovative products and services [35].

Certainly if innovation is to flourish, R&D is essential. Sir Paul Nurse, president of the Royal Society, claims that in the UK, R&D per head is less than half of the figure for the US and Germany. In 2010 UK national spending on R&D was £26.4bn [36], or 1.78 per cent of GDP, down from 1.84 per cent in 2009. Many government agencies exist to allocate funding to private and public sector projects. Universities have driven much exciting work, most successfully when in partnership with the private sector. However, industry commentators point out that big problems need big solutions, and further note that, since the privatisation of the CEGB, energy R&D in the UK has greatly diminished.

Support for game-changing innovation such as large-scale electricity storage is vital. The last big project of this kind in the UK was in Dinorwig, North Wales: begun in 1974 and opened 10 years later, it is a pumped storage scheme that can generate 1.8GW in less than 16 seconds. To support Germany's Renewables Programme, Norbert Röttgen [37], until recently Federal Minister for Environment, put €200m into R&D on storage options for 2012 alone, but admitted that this money was allocated to a bewildering array of projects.

An even more significant game changer, due to its vast range of potential

applications, is graphene: carbon sheets one atom thick, with a very high strength-to-weight ratio. Research into this material includes its potential use to create lightweight wind turbines and less heavy aircraft components, resulting in less fuel consumption. It may also improve both energy capacity and charge rates for rechargeable batteries, and be used to build inexpensive, lightweight solar cells. A £50m fund has been awarded to Manchester University to continue its pioneering work on graphene, compared with the $300m already allocated by the Republic of Korea for university research in the same field. Commentators suggest that the size of the award ought to be compatible with the contribution such innovation could make to society. If energy is a public good, then the "prizes" should be of a magnitude to enable progress. A UK government-funded £1bn prize for a CCS project remains unclaimed, since prospective participants claim that this is insufficient; a minimum of £1.5bn is required to get CCS off the drawing-board.

Correctly targeted, R&D can have positive results for nascent industries. In 2008, the Labour administration launched a three-year, £9m feasibility study of the Severn Barrage, a tidal barrage on the Severn Estuary between England and Wales. Ostensibly an updated cost/benefit analysis of the historic barrage design [38], the study stimulated the UK's emerging tidal power community to design numerous innovations, to the degree that the budget was extended by £500,000 for further individual R&D projects. As with previous reviews, the 8640MW barrage itself was rejected on economic grounds rather than environmental ones. However, important lessons were learnt and two new proposals are back on the table: one from Corlan Hafren, a consortium including engineering experts Halcrow, Arup and Mott MacDonald, and one uniting Rolls Royce with WS Atkins. Yet on another front the same government stalled tidal stream development dramatically through the mismanagement of its £50m Marine Fund. Due to unrealistic qualifying criteria, including three months of sea trials, the Fund remained unspent. As a consequence a golden opportunity to support early-stage prototype technology was missed.

5. DEVELOPING SKILLS FOR NEW LOW-CARBON MARKETS

Many economists pessimistically suggest that supporting unviable industries can only ever destroy jobs, because of the inefficient allocation of capital. Yet few political speeches on the low-carbon economy omit assurance that thousands of new jobs will be created. In his speech at the September 2010 Liberal Democrat conference, Energy Secretary Chris Huhne promised to create 250,000 jobs in green industries. Three years ago, President Obama promised US citizens "millions" of new green jobs; they have failed to materialise. Research into the Spanish model, on which Obama's hopes were pinned [39], suggests that the US should expect nine jobs lost for every four "green" ones created; indeed since 2000 Spain has spent €571,138 on creating each green job. A similar conclusion was reached by Verso Economics [40], which found that, for every green job in the UK, 3.7 jobs in the wider economy are lost. Fankhauser et al [41] would argue that the long-term employment potential lies in the growth and diffusion of innovative products and services that may spill over into a number of different sectors. Strietska-Ilina et al suggest that skills and training must not simply focus on new green jobs, as "while few new occupations emerge in the transition to

greener work, massive change occurs in existing occupations" [42]. Changes in skill profiles will happen at all levels of qualifications across all sectors; training initiatives must be relevant to labour market needs. If the UK is to stimulate growth in the short term, it must prepare its existing workforce, as well as the scientists, engineers and entrepreneurs its low-carbon future will demand.

6. CONCLUSIONS

It is clear that the market will not deliver the government objective of decarbonising energy and the economy, at least not on the envisaged timescale. While government intervention would appear to be unavoidable, care must be taken to strike a balance between generous incentives that see the large-scale deployment of existing mature but low-impact technology, and funding more efficient, cost-effective, innovative approaches to a low-carbon future. There is a danger that simply rewarding capacity encourages mass application without any incentive to improve technical performance or to drive down costs, thus ensuring a perpetuation of subsidies to prop up otherwise unviable technologies. Also, because subsidies such as ROCs and feed-in tariffs are paid for through consumers' utility bills, such a resource should be more sustainably targeted, as there is a limit to what the consumer can afford. Support for mature technology that fails to perform either on price or efficiency should be withdrawn. The aim should be to make all technology subsidy-free on an agreed timescale. Innovation in low-carbon technologies can be encouraged through government intervention such as procurement, which can have a dramatic impact on bringing emerging technologies to early commercialisation, as experienced in the US. Finally, the UK needs to make a substantial increase in targeted R&D, complemented by a framework of continuous support for skills and training to prepare for the transformation of existing occupations, in addition to creating new "green jobs".

As for political intervention, the government is currently undertaking the greatest exercise of this kind for nearly 30 years with its Electricity Market Reform. It needs to prove that lessons have been learnt to keep prices reasonable and thus consumers on side. Primarily, though, restoring investors' confidence is vital if investment in new generation capacity is to go ahead. Whether the EMR proves to give the stability and clarity to the market that investors seek, only time will tell.

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Author

Candida Whitmill is an entrepreneur with business interests across a diverse range of sectors. As a previous advisor to the UK Labour Government on the impact of energy policy on businesses, she continues to advise and write on energy policy, both for the UK and Europe. Candida assists businesses to bring new energy technology to market and currently heads a British-led consortium with an innovative approach to bringing the UK new nuclear investment. She is also chairman of the Tidal Power Forum.