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Will markets deliver low carbon power generation?

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ABSTRACT

This paper questions whether UK competitive electricity markets, as currently configured, will deliver the low carbon power sector that is a necessary condition of meeting ambitious UK CO2 emission targets. It analyses their historical development within an essentially fossil based system, and potential weaknesses in relation to low carbon investments. These include concerns over operational, capacity investment and retail tariff issues, and over carbon price signals emanating from the EU ETS. It concludes that careful monitoring is needed to ensure that market structures reflect changing technologies both in generation and consumption, and do not inhibit essential low carbon investment.

Key words: **electricity, carbon, markets, competition**

1. Defining the Question

There is an implicit, sometimes explicit, assumption in current Government policy[1] for the reduction of UK carbon emissions that markets will play a major or leading role in the delivery of emissions targets. While few would dispute the central importance of markets in energy policy in general, and their potential value in driving efficient solutions to environmental problems, this assumption deserves critical review. Perhaps the most obvious argument for a careful critical analysis is, to paraphrase the Stern Review[2], the observation that the link between emissions and climate change constitutes "perhaps the biggest market failure the world has ever seen". If the issue starts with an identification of market failure, ie failure to provide the efficiencies and optimal outcomes that should flow from a functioning competitive market, then market solutions need to address existing market imperfections as well as Stern's core externality.

This implies the greatest possible care in examining all policy instruments in relation to electricity markets, to deal with the risks of further market failure arising from possible flaws that are already present in those markets. Governments have played a major role in setting up both the market structures and the regulatory policies and mechanisms that currently define electricity markets. Given the growing importance of action on emissions, the necessity for Government oversight of markets and regulatory policies, to obtain assurance that they are meeting, and will continue to meet, fundamental policy objectives, is clear.

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[1] Meeting the Energy Challenge, A White Paper on Energy, *Department of Trade and Industry*, May 2007

[2] Sir Nicholas Stern ,The Stern Review on the Economics of Climate Change, *HM Treasury*, October 2006,

This systemic concern with energy issues is strongly analogous to the well established and very topical necessity for the oversight of financial markets and their regulation. If markets are likely to prove inadequate or vulnerable to systemic failure, for whatever reason, then attention needs to be given either to reform of the market, or to the alternative policy instruments of regulation and direct intervention (eg through research or investment).

The natural first step in response to the challenge, as correctly argued by Stern, has been to consider how best to internalise the costs of emissions, whether through properly designed taxation or through the development of emissions trading within an overall emissions limit – the EU ETS (Emissions Trading Scheme) currently being the prime manifestation of this approach. This reinforces the importance of examining the adequacy both of this trading scheme and of the existing market structures with which it operates within the UK. We need to consider whether energy markets, as currently organised and structured in the UK, are capable of or compatible with efficient delivery of large reduction targets over ambitious timescales, and with the degree of urgency that these targets imply. We should also identify what kind of market reforms, or additional regulatory and investment measures, might be needed to ensure that the policy can be delivered.

The particular importance of the power sector, on which this paper concentrates, arises both from its intrinsic importance as the largest single source of emission reductions, accentuated by potential future substitutions of new low carbon electrical energy for traditional use of fossil fuels in transport, and because the relevant policy measures for electricity are more directly within UK control than for some other sectors. Moreover, it will be argued, ambitious aggregate targets for 2050 require early progress to an essentially carbon-free power sector.

General requirements for electricity markets to meet, almost regardless of the policy context, in order to be deemed functional and to meet the objectives of securing efficient provision of supply, include:

- demonstrating the ability to generate the right levels of investment in maintenance and replacement of sufficient capacity to maintain a secure supply and, where required, new capacity and associated infrastructure. This means that markets have to provide price levels that deliver a return on the investment required, and do not contain significant barriers to entry.

- allowing short term organisation of generation to maximise operating efficiency through the scheduling of the most efficient plant. This means that wholesale prices have to be closely reflective of marginal cost.

- allocative efficiency, in providing prices for consumers that accurately reflect the marginal costs of supply, and hence give them the correct incentives for their own choices in fuel use and across a wide range of their own investment decisions, for example in housing and transport. Prices that are too low will encourage wasteful consumption; prices that are too high may give the wrong signals for fuel substitution.

- an industry structure that provides a genuinely competitive environment, so that competitive pressures can operate to encourage innovation and efficiency at all points in the chain of energy production, distribution and use.

To be fully effective in the context of policies for reducing CO_2 emissions, electricity markets have to meet all of these requirements in a way that is fully consistent with delivery of emissions policy targets or objectives, and with the associated degree of urgency. Moreover the markets have to find, or be given, some way of incorporating the externality associated costs of emissions. Only if all these conditions are satisfied can markets be considered fully effective as an instrument of CO_2 emissions policy.

In considering these questions we start with the 1990 genesis and subsequent historical development of UK electricity markets, and examine some of the necessary conditions for a low carbon future, in order to analyse the potential problems and draw conclusions on what might be the major problem areas.

2. The 1990 market structure

The circumstances surrounding the design and construction of the new markets to be put in place to accompany the privatisation of the power sector in 1990 have largely determined both the market structures that followed and the terms of debate.

2.1. Main objectives in designing the 1990 market.

Functioning and efficient markets do not always arise from the natural interplay of the forces of an unconstrained laissez-faire environment. In reality many depend on initial regulatory intervention and have the features of a club, carefully regulated with rules designed both to protect market participants and society at large from opportunistic, dishonest or destructive behaviour, and to ensure the most efficient outcomes. This is particularly so where the products or commodities being traded are complex and multi-faceted. Nowhere has this been more true than in the case of electricity, which has the additional complications of a network industry in which the process of production of the commodity, kWh, is also intricately related to the stability of the system and the maintenance of the quality of supply to consumers. All these factors are exemplified by the complex arrangements that were put in place in 1990 with the privatisation of UK electricity and the UK power sector.

Prior to 1990 there were few if any examples of “true” markets in electricity, the closest being some of the power pooling arrangements between utilities in North America. In their effect these replicated the merit order system of the old CEGB through a “generators’ pool” which minimised collective short term operating costs, but with an agreed sharing of efficiency gains rather than market prices and trading.

The development of UK electricity markets at privatisation in 1990, and the England and Wales Pool in particular, has to be set in the context of the primary objectives and concerns at that time for the design of a sustainable power generation market which would assure the continuing development of a power sector. It is worth reviewing what the concerns were in the 1990 market designs, how they were met, and what this might tell us for the future. The main objectives were:

- Maintenance of the benefits gained from the old CEGB merit order, a generally admired feature of the old nationalised industry operational arrangements, which sought to optimise short term operational efficiency by mimicry of a market structure and internal “competition” between stations to increase thermal efficiency and reduce fuel costs in order to be “in merit”. This resulted in least cost despatch of plant based on their position in the merit order.

- Technical stability of the power system, requiring some means of continuing or substituting the “command and control” features of the National Grid in order to ensure continuity of a reliable supply.

- Adequacy of incentives for investment in long-lived highly specific non-mobile assets, and a sector that would remain financially viable under private ownership within a framework that included both competitive markets and monopoly regulation. Asset specificity, and the risks of regulation around consumer prices make it particularly important for investors to find means of reassurance on the long term security of their revenues.

- Confidence that there would be actual investment under the new market rules, given that the old statutory “obligation to supply” requirement placed on the CEGB, would no longer exist for any of the new entities or would exist only in an attenuated form.

- Limiting the ability of large generators to dominate the market, particularly given the decision to create only two major fossil generators in England and Wales, and uncertainty over how this could be addressed through conventional competition policy

- A political imperative to create structures which allowed retail competition

All these factors are to some degree inter-related, and all had powerful influences on the actual development of the sector and its associated markets.

It is worth noting that this was a system that was essentially fossil fuel based; the market was therefore for all practical purposes designed around the technical and economic characteristics of fossil plant connected to the transmission grid. There was an awareness of the particular issues posed by plant of limited flexibility, and of particular issues that might be created by “decentralised” plant embedded within the distribution system and not subject to central despatch. On the whole these were at that time felt to be either intra-marginal, or too limited in scale to be significant.

It is also worth noting that a competitive structure militates strongly against use of the electricity sector as an instrument of policy, whether with regard to fuel poverty, support for domestic industry, or imposition of fuel choices. In particular it is not possible within a competitive market to impose a residual “obligation to supply” on any individual company within the structure. To do so would destroy their competitive position.

Of course the removal of public ownership as a potential instrument of policy was widely seen as one of its advantages. Ministers could no longer be held responsible for the problems of the UK coal industry for example. The implication for energy policy was that instruments of policy would henceforward need to be carefully constructed around the existing market structures. The first example of this was to be the treatment of renewables under the non-fossil fuel obligation (NOFFO) and its subsequent manifestations in other forms. The policy instrument of a simple directive (to the CEGB) was no longer available.

2.2. Merit order.

The traditional and longstanding CEGB approach to the despatch of generation plant had been through the establishment and maintenance of a "merit order" ranking of plant by ascending order of the short-run costs of operation; for all practical purposes this amounted to a ranking by fuel costs per kWh of electricity generated. As load changed up or down through the day, plant would be added or taken off according to its position in the merit order, which itself could change if the relative input costs or efficiencies of particular plant varied from day to day, or over longer periods, as a result of either technical or economic factors.

The new wholesale market structure, known as the Pool, closely reflected this approach to despatching plant. The half hour period taken as the basic unit of time for bidding into the market, detailed rules governing the content and nature of bids, and the development of pricing rules, were in many ways precise reflections of previous CEGB working protocols. As such they were a practical compromise between the realities of instantaneous load shifts, the longer periods over which plant can vary output and the complex "power engineering" task of maintaining stability in the system.

The pricing mechanism itself was designed to set wholesale prices on the basis of what would previously have been recognised as a system marginal cost, ie the cost of the least efficient plant in operation during that half hour. This translated under the new regime into a system marginal price calculated from the bids placed for half hourly periods through the day of marginal running costs, with the implicit assumption that, at least within a properly competitive market, the individual generating stations would have an incentive to bid in their "true" marginal running costs.

Generating plant would make a profit, or rather a contribution over and above fuel costs, when it was within merit and could operate for a lower cost than the system marginal price. This contribution would provide at least part of the necessary revenues to make a return on capital employed and meet other fixed costs.

Even in 1990 there were categories of generating plant that did not conform to what was essentially a model designed for a fossil fuel based system. The approach was imperfect even for much relatively inflexible fossil plant, as well as for nuclear plant which was not capable of easy output adjustment except at high cost, or for the particular characteristics of renewables. It is not a particularly useful mechanism for generating prices in circumstances where short run marginal cost is effectively zero or negative. However at privatisation it was felt these imperfections could safely be ignored as intra-marginal, and that they did not detract significantly from the theoretically sound characteristics of the new framework.

Prices were constructed on the basis of a system which for a very high proportion of the time would be based, for all practical purposes, on system marginal cost (SMC). This made a great deal of sense in a system of fossil plant where fuel accounted for perhaps 50% of the aggregate cost of generation even in an era of low oil (and gas and coal) prices. However the actual technical characteristics even of fossil plant do not conform perfectly to the rules of a theoretically pure on-off system of half hour costs and prices.

2.3. Adaptation to meet technical stability

The power system cannot be described solely in terms of kWh production by competing generation plant. Maintenance of system operation and stability requires that plant to be subject to centralised control, to observe particular constraints, and to provide particular services to the grid in terms of reactive power, frequency control, cold start facilities and a variety of other services. These services in turn are linked to characteristics and constraints imposed by the current state of the transmission system and the power flows within it. These had to be dealt with through a mixture of license and grid code requirements, together with financial incentives or recompense to generators. Many of these characteristics of a rule based system were inherited directly from the command and control system of the old CEGB, and will persist in some form in any future integrated system.

To a very large extent these were the rules of a club of fossil generators. The technical features of the market were designed in large measure by people who knew how the power grid operated and knew that they would be commercial players within the new arrangements.

To a significant degree these technical requirements also explain what is sometimes criticised as the Byzantine complexity of both the Pool and subsequent NETA/BETTA trading arrangements. However it is important to appreciate that the nature of these rules can have profound implications for the profitability of different types of plant, and hence for the economics of choice in respect of new investment. This, and the potential for intrinsic bias towards fossil plant, is a major issue and is explored more fully in the later analysis.

2.4. Reward for capacity

It was immediately clear, in terms of the theory of this SMC market paradigm, that a Pool or wholesale price based only on matching system marginal cost could not be guaranteed to provide overall adequate capacity to meet load at all times, and would fail in terms of generation security. This is easily demonstrated by taking the example of plant that is only "in merit" and called upon to run at times of peak. If it bids in its true running costs, then it is rewarded by a market price exactly equal to that cost, leaving a zero contribution to overheads, other fixed costs and capital costs. Hence there is no incentive to maintain the "peaking plant" necessary to ensure ability to meet peak loads and avoid supply interruptions.

The 1990 solution to this problem was a theoretically elegant device based on loss of load probability. If the system were to approach a situation of potential physical shortage, in which demand was likely to exceed available generation, then the pool price would become the value of lost load times the loss of load probability.

Generation security was further reinforced, initially, by establishing an obligation to supply for the public electricity suppliers (PES). This took the form of an obligation to meet demand by purchasing on the market at any price up to the value of lost load (VOLL). This supplanted the statutory obligation to "meet all reasonable demand" previously placed on the CEGB. The level of VOLL was set at a level that would in principle maintain the pre 1990 level of generation security. This theoretical continuity in the standard of generation security was achieved by setting a particular value of lost load that was considered to correspond closely to the value implicitly embodied in the CEGB's earlier level of generation security and planning margin (of capacity surplus).

2.5. Competitive structure

An important innovation of the new regime, in terms of competitive structure, was that what had begun, conceptually, as a generators' pool, originated from a US model of sharing the gains from trade among utilities, was now open to a much wider category of membership, including the new supply and distribution companies. This was an essential innovation to meet the political imperative of creating structures which allowed the development of retail competition, since it opened up the option for supply companies, or even large consumers, to buy directly from the Pool. This anticipated, in the longer run, a much more active participation of the demand side of the market. The new regime drew a clear distinction between the business activities of distribution and supply.

The initial 1990 configuration of the market in England and Wales was built around the break-up of the old monopoly CEGB into two large fossil fuel generators, and the nuclear plant which remained in public ownership until 1996. Surplus capacity in the market in 1990 translated into low prices and hence very low asset values for the generating companies within a competitive market.

However the assumption of new entry proved correct, driven initially by the strong ambitions of the new distribution and supply businesses created in 1990. Having seen themselves as being at the mercy of the old monopoly CEGB, these companies, newly privatised, were anxious to secure their own sources of generation. Encouraged by regulatory mechanisms which initially allowed a degree of pass through of generation costs, and taking advantage of the new opportunities afforded by CCGT, a variety of joint ventures in generation were established very quickly at privatisation in 1990.

Initially the impact of competition was constrained by contractual arrangements for three years, a primary purpose of which was to provide a transitional period in which UK coal would enjoy a degree of protection against imports and competing fuels.

3. Subsequent development of the market

3.1. Fuel choice and the effect on prices

UK privatisation and the new market structures more or less coincided both with the advent of new technology in the form of combined cycle gas turbine (CCGT), giving significantly higher efficiencies and lower generation costs, and with a sustained period of low and falling fossil fuel prices, especially for gas. Gas was subject to its own reforms, and the end of BG's purchasing monopoly in the North Sea may also have contributed to falling gas prices. Among other things, these factors dramatically accelerated the decline of UK coal, and quite rapidly changed the sector fuel mix. There were two important consequences of this fortuitous combination of circumstances.

First there was a substantial decline in real prices to consumers, beyond what might be attributed to increased efficiency. This could be claimed in part at least as a benefit attributable to the virtues of competition and regulation within a private sector environment. A significant contributory factor was the sale of the generators at significantly below book values and the absence of public sector rate of return targets and tariffs based on much higher asset values, which were in any case not attainable in a competitive environment. However these factors were enhanced and sustained by falling fuel prices and the cost advantages of CCGT plant.

Lower consumer prices normally raise consumption, and indeed there was a significant expansion of electricity demand in the 1990s. Residential electricity consumption, having been virtually static for at least a decade, surged by just under 25% over the next 15 years, a major part of this almost certainly being attributable to a resurgence in the use of electricity for space and water heating, driven by a combination of rising real incomes and falling real prices in this period. This is of course a negative from the perspective of policies seeking to contain energy use and emissions.

Second the displacement of coal for gas resulted in a significant decline in CO_2 emissions. This was an important environmental gain and has enabled governments to claim significant post 1990 reductions in emissions. This gain was however to a large extent fortuitous, since it was not driven by environmental objectives, and was essentially a by-product of the introduction of CCGT technology at a time of low gas prices, and the displacement of more CO_2 intensive coal.

This enabled governments in some senses to have it both ways – with lower prices and a more environmentally friendly power sector, even though lower prices had driven a major increase in electricity consumption.

It is only recently that the structural reforms set in train in 1990 are facing what may be a more challenging environment in relation to emissions reduction, with declining supplies and rising prices for gas. There are now pressures for more coal plant, and consternation at the prospect of rising consumer prices.

3.2. Market Rules

When the electricity industry was privatised in 1990 and the original trading system, the Electricity Pool, was created, there were no reference models from which to take or adapt a design. The system was designed, implemented and owned by the electricity industry and it was generally conceded that it performed well against a number of important criteria, not least in maintaining the integrity of the system control function and avoiding supply disruptions through technical or market failures.

Nevertheless there was significant dissatisfaction with the Pool arrangements which went beyond what might have been resolved through minor tinkering with the rules. This reflected a number of factors:

- the undeniable truth that the sector had been privatised with just two competing players capable of setting prices at most times, limiting the impact of competitive pressures. Nevertheless by the time NETA was introduced in 2001, new entry had brought about a substantially more competitive framework.

- belief among some of the major players in the market that a less transparent system of bilateral trading and pricing would enable them to gain commercial advantage.

- instinctive but visceral dislike, particularly among free market purists, of the "administered" LOLP/VOLL approach to the capacity charge component, and of a system marginal cost (SMC) rather than a "what you bid is what you get" (or "wybiwyg") approach to constructing the wholesale "balancing" price.

- some obvious omissions from the original Pool, such as the incorporation of demand side bidding

This led in 2001 to a more fundamental change to the nature of the Pool and the restructuring of the market under the NETA arrangements, later re-titled BETTA with the inclusion of Scotland within the trading arrangements.

Whatever the other merits and demerits of NETA compared to the Pool, the following features of the changes are potentially important to any analysis of compatibility with policy objectives for reducing CO2 emissions, as well as for the general health of the electricity market:

- the basic economics of merit order operation continued to be reflected at least in the energy/ SMC component of wholesale prices.

- the VOLL/LOLP basis for capacity was abolished and not replaced by any alternative form of capacity payment; there is in consequence now no obvious source of reward to capacity beyond what can be earned through bilateral trading and balancing payments

- the “command and control” features of the old CEGB system necessarily continued under the regime, which in consequence has continued to attract criticism, as did the Pool, for its Byzantine complexity

- within this complexity, NETA remained a system designed primarily for fossil plant and for flexible fossil plant in particular; it was widely criticised as penalising renewables and it certainly damaged the commercial return to British Energy’s nuclear plant. It is hard to judge whether these penalties on non-fossil plant were truly justified even from a narrow cost perspective of minimising short term fuel costs, since the majority of market participants would have had some vested interest in lobbying to favour fossil plant. This criticism raises important questions for a low carbon future.

It would later be claimed that NETA resulted in further falls in wholesale market prices, although it is hard to measure whether this was due to abolition of the capacity charge, to changes already in train that reduced concentration and market power in the industry, or to any efficiency or increased competitiveness associated with NETA per se.

3.3. Competitive structure

Supply competition was extended quite rapidly from covering only the largest consumers to covering the totality of consumers by 1998. Consonant with this the residual obligation to supply, which had rested with the “public electricity suppliers” at the time of privatisation, disappeared and was not replaced by any new mechanism.

Extension of retail competition was allowed to develop on the basis of load profiling rather than on the basis of more complex metering, introduction of which would have slowed achievement of the politically important goal of declaring the market to be fully competitive. Load profiling can be considered as another arbitrary administrative device within the market structure. It averages all load of a particular class, in this case domestic, ignores differences in actual consumer load profiles by time of day or year, and hence reduces very substantially the possibilities for full allocative efficiency in this part of the electricity market.

The initial 1990 structure had emphasised the “unbundling” of the old publicly owned industry into a structure which separated the functions of generation, transmission, distribution (regional or local) and supply. Generation and supply were considered competitive businesses, and transmission (national grid) and local distribution were subject to price regulation.

Despite some initial unease at the prospect, subsequent developments have nevertheless been strongly in the direction of vertical integration, with the re-integration of generation and supply being the most significant in terms of competitive structure. A substantial degree of vertical integration has been allowed to develop within the industry and has come to be perceived as a major strategic advantage. This is also a factor tending to raise barriers to entry to the generation business.

It is an open question whether consumers, particularly smaller consumers, have benefited to a major degree from retail competition. A useful presentation of this position is given by Joskow.[3] Given that wholesale prices and "regulated monopoly" distribution charges should account for almost the totality of the final retail price, with little "value added" in supply, one would expect, in a competitive market, very little difference in suppliers' retail prices. The frequent lack of transparency in retail tariffs, and the exploitation of customer inertia among those who do not switch supplier regularly, suggests that the gains, for the consumer, from retail competition, may have been overstated. The strategic importance attaching to vertical integration suggests that suppliers collectively may have been the main beneficiaries.

4. Future factors

4.1. Accommodation of carbon markets

Now and for the foreseeable future, electricity generation in the UK is likely to be covered by emissions trading arrangements. These are incorporated into Pool/NETA type markets with comparative ease, since bids will simply include the value of CO2 permits in the same way that they include fossil fuel costs.

This serves to emphasise, however, that the achievement of overall policy objectives depends on the feasibility and compatibility of the targets and associated mechanisms.

4.2. The necessity for generating plant that is low or zero carbon

It is clear that if the UK is to meet its CO2 targets, then a power generation sector that is essentially carbon free is a necessity. This has been argued strongly in earlier papers by the BIEE Climate Change Policy Group[4]. In essence this assertion derives arithmetically from the combination of the objective of a 60/80 % reduction in CO2, the current electricity contribution of some 35%, and the prospect of relatively slower progress in the other sectors.

Carbon-free electricity implies very substantial growth in the collective contribution of the following categories, and some or all of these will have to expand very dramatically:

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[3] Paul L Joskow, "Why do we need electricity retailers? Or, can you get it cheaper wholesale?", *Center for Energy and Environmental Policy Research, Massachusetts Institute of Technology*, revised discussion draft, 13 January 2000.

[4] John Rhys Mike Parker and Gordon Mackerron, Shaping Carbon Budgets, , January 2008,and related papers on the site *Bringing Urgency Into UK Climate Change Policy*. http://ccpolicygroup.blogspot.com/ This is a BIEE linked site.

- Nuclear
- Carbon capture and storage (CCS)
- Centralised renewables
- Decentralised renewables

All these non-fossil sources are likely to have very different technical and economic characteristics from fossil plant. A common characteristic is that they may place a premium on means of electricity storage or on matching with more flexible types of electricity demand.

Nuclear plant is typically regarded as the most inflexible, albeit this has not prevented the French from running a very successful power sector with a very high contribution form nuclear power. The reasons are a combination of technical and economic. Nuclear power output can typically be varied but for some plant this can have implications for more frequent routine maintenance schedules, reflecting safety and licensing requirements, and with large additional maintenance costs and reduced annual output. In economic terms therefore, nuclear plant is often described as “must run”, and might even bid a negative price within a market system that permitted negative bids. These characteristics will not be the same for all plant, and there will be incentives to design future plant to be more flexible, with lower cost penalties for flexible operation.

The characteristics of future CCS plant are unknown. In principle one might expect it to be similar to equivalent fossil plant, but at this stage there is no information on which to make predictions, for example, of whether or not the proportion of carbon captured in combustion is likely to vary with output level. If it did then load following would have a strong effect on the economics of CCS plant, and on the way that it could be bid into a market of the Pool or NETA type.

Renewables covers a range of technologies, with very different characteristics for wind, tidal and other sources. Typically they may be flexible in the sense that output can be turned down when the plant is available, but inflexible in the sense that they cannot deliver when not available (eg wind turbines in the absence of wind). Decentralised renewables are not normally regarded as part of the centralised control system, but they will need to be accommodated within the broader market framework of tariffs etc.

4.3. A more electric economy

The significance of electricity in achieving a low carbon economy is not confined to finding low carbon or carbon-free alternatives for the production and consumption of electricity in its current uses, since carbon-free electricity, whether generated in centralised or decentralised systems, also provides a number of the known technically feasible alternatives to fossil fuel use in both transport and the heating of buildings, the two other largest categories of energy use and hence sources of CO2 emissions in the UK.

In transport this includes both the possibility of electricity in transport, including battery operated vehicles, and the use of hydrogen, carbon-free production of which currently depends on electrolytic methods and hence electricity.

A significant proportion of total electricity requirements to meet the needs of battery charging, or of a hydrogen economy, will have one additional practical advantage, that it provides a vector for the storing of the energy generated as electricity. This could, assuming appropriate use of time of day pricing signals, remove much of the power sector's peak load problem, and as a corollary reduce the disadvantages of the intermittent availability of renewables.

In heating of buildings, the main current uses of electricity are through conventional direct acting heaters and storage heating, but the novel use of electricity dependent technologies such as ground source heat pumps is also potentially important. As with the transport sector a significant penetration of electricity in the heating market would have a major effect.

The buildings sector may also be associated in part with a decentralised component to electricity generation, for example through individual household ownership of small wind turbines. To be effective, and in economic terms, efficient, this would require purchase and sale tariffs for consumers that were fully cost reflective at the level of the individual household, and hence an abandonment of the load profiling approach in favour of more sophisticated metering and more complex time of day tariffs.

5. Analysis

In the context of developing a low carbon future, a hugely important requirement of the electricity market, not present or not emphasised at the time of the 1990 privatisation, is its compatibility with investment in and successful operation of the low carbon technologies that will form the basis of power generation and electricity use in that future, together with the ability to assure a very low carbon contribution from the power sector. We analyse the prospective development of power markets, wholesale and retail, from this perspective.

5.1. Operational security and efficiency

An essential feature of the market is that it should continue to deliver efficient short term operation and cost minimisation, and system stability. The market will have to change to accommodate the operational realities of the low carbon plant that will in a low carbon world constitute by far the larger part of generation, and it seems inevitable that plant with the very different characteristics of relatively inflexible or intermittent plant, with fossil plant no longer at the margin, combined possibly with a much greater significance for demand side bidding and management (eg for battery charging or hydrogen production) will require a very different approach to the development of bidding systems and a very different approach to the optimisation and scheduling of load. If, as seems probable, the economic advantages of a national grid remain overwhelming, then the centralised optimisation, currently effected through a half-hourly based bidding system, will need to be done either through a wholly different type of market, or will have to be returned to centralised control.

It is quite possible that the basic building block of half hour bidding periods, for example, will not be suitable to guarantee the optimisation of more complex systems. Comparison can be made with complex hydro systems involving water storage for example. If the existing system were retained it would inevitably distort the market towards particular types of plant. One would normally expect to see a piecemeal evolution to a completely new optimal system, but it must be an open question as to whether the structure can actually evolve in that way, depending as it does on agreement between existing market participants. Failure to resolve this issue could be construed as a potential barrier to entry of non-fossil plant.

5.2. Correct signals for new investment

A vital attribute of a properly functioning market is that it should deliver prices that provide the correct signals to producers and suppliers for future investment. To be efficient in economic terms prices should reflect the appropriate measure of costs at all points in the supply chain, and not be so high as to promote excessive investment or so low as to promote excessive consumption and inadequate investment. Prospective investors need a market that delivers prices capable of rewarding their investment, including the recovery of operating costs and an adequate return on capital.

This places a number of requirements on the market and institutional structure, including the mechanism for internalising the "cost" of emissions, and the stability and credibility of the regulatory and policy structures within which the market operates.

One outstanding issue in this context, however, is at the core of the current market structure. It arises from the abolition of the Pool payment for capacity through the administered market LOLP/VOLL mechanism intended to reflect the value of lost load. This was previously seen as an essential feature of the Pool, necessary to reward "peaking plant", plant required only at peak periods. Ultimately this may be an empirical matter, but at least from a theoretical perspective it appears far from certain, if not a leap of faith, that NETA based prices will deliver adequate rewards for capacity, and hence that the market is capable of delivering new capacity.

To quote Dieter Helm[5]: "The NETA-type market was deliberately designed to drive down prices. …..But at the heart of NETA lies a flaw, a flaw that did not much matter as long as there was excess supply. NETA did away with the capacity element of the market in the Pool … and introduced greater volatility. Under NETA, investment would be stimulated because as demand and supply came into closer contact, the price would rise to the level necessary to trigger investment. But in electricity markets, because supply *has* to equal demand *at every point*, there needs to be a capacity margin. But that spare capacity is not independently rewarded under NETA – it only gets paid for if prices occasionally reward it. Investors, in effect, take a bet on occasionally winning the lottery." Similar points are made by Graham Shuttleworth in a review[6] of the NETA framework.

Helm suggests that this might work in theory, although even this is a moot point, but is unlikely to work in practice. "As soon as the price starts to spike, politicians are inevitably drawn into the frame. They were in California, and they have been here. Even the slightest suspicion that the prices may not be allowed to spike deters *future* investment. Hence investment is sub-optimal." This may not have mattered in recent years, when there was a margin of surplus capacity, but eventually new investment becomes necessary. So far, Helm notes, NETA has not supported *any* significant investment.

This of course would be a potential defect in the market even in the absence of the need to accommodate a low emissions policy for the sector. However the combination of the absence of a clear reward to capacity, combined with the regulatory uncertainty identified by Helm, and any residual or additional uncertainties over the consistency of government policy for a

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[5] Dieter Helm, Hot air, gas prices and energy policy, December 2005. www.dieterhelm.co.uk/publications/December05.pdf

[6] Graham Shuttleworth, Pay as Bid Balancing Market Runs into Trouble in the UK, *NERA Energy Regulation Insights*, April 2004. http://www.nera.com/NewsletterIssue/ERI_Issue%2020_April%202004-updated_4.2006.pdf

low carbon future, adds up to a significant deterrent to new low carbon capacity and potentially a much slower rate of installation.

5.3. The Impact of the EU Emissions Trading Scheme

The EU trading scheme is central to the efficacy of electricity markets in relation to emissions and carbon policy since it is the only route through which the internalisation of the cost of CO_2 emissions takes place. The adequacy of the EU arrangements therefore impact hugely on confidence in the ability of UK electricity markets to deliver their contribution to UK emission reduction targets.

In principle, a strictly monitored and enforced limit and associated trading system, consistent with the policy objective, should be capable of delivering a market solution. In practice the first phase of the EU ETS, even if successful when measured against the limited objectives of a pilot scheme, had a number of serious inadequacies when viewed in a wider context. Created from scratch to operate across many different political jurisdictions, it suffered many of the teething problems of a new market. Its effectiveness was also severely limited by the lobbying of national governments acting in the special interests of their own industries.

Its most serious longer term deficiencies, from the perspective of a policy for UK emission reductions, are threefold. First it is questionable whether it can bear the weight that the UK Goverment puts on it as a main instrument of policy. An important concern here is the political plausibility of the expectation that the carbon price will be allowed to reach the kinds of levels needed to induce strongly pro-low-carbon investment. Second it is questionable whether it is sensible to rely on, as a flagship instrument, a policy measure over which the UK Government has only limited influence. In effect this puts a national policy in the hands of an EU bargaining process. Third, grandfathering of emission rights is economically inefficient and has generated large windfalls.

At the very least this poses some fundamental questions for the integrity of future schemes. In addition a number of more technical questions need to be asked of the second phase and future arrangements of the EU ETS, and of its consistency with any UK aspirations for UK CO_2 reductions.

- Is it compatible in terms of both its coverage and the actual emission limits set? In what sense can EU targets be said to correspond to UK targets? And how do they match for the electricity sector in particular?

- Are the timescales compatible? This question is particularly apposite viewed in the context of investment against a 2050 commitment, given the much shorter timescales against which EU agreements are currently framed and uncertainty over the nature and timing of future changes.

- Some commentators have suggested a danger that the scheme injects an artificial volatility into the price of energy. This would be a further inhibition to investment, particularly in the low or zero carbon sources of generation that are required.

5.4. Delivery of price signals for allocative efficiency

To achieve allocative efficiency, energy markets need to produce price signals that reflect correctly the costs incurred in delivering that supply of energy to them. This gives producers and consumers incentives to make rational decisions about their own expenditures, and rational choices between the fuels available to them, while paying an amount that covers the market and production costs associated with supply. Prices that are too low encourage wasteful and frivolous consumption, ie consumption that is valued by the user at less than its actual cost to others or to society as a whole to deliver. Prices that are too high unnecessarily discourage consumption or may cause consumers to substitute in favour of products that actually have higher costs. Prices that do not consistently reflect costs across different fuels, especially in the treatment of emissions costs, will diminish the overall efficiency of the energy economy, and may result in higher emissions than would otherwise have occurred. The importance of allocative efficiency in relation to consumers will necessarily tend to be higher in a period of generally higher fuel prices.

The significance of allocative efficiency in the electricity sector is enhanced by the fact that there can be dramatic short term marginal cost variations in generation. These are likely to be accentuated very dramatically as electricity generation moves from a mainly fossil based system to a mainly carbon-free system, from zero costs when nuclear or renewables are at the margin to very high values, perhaps a multiple of current retail prices, when fossil plant, costs enhanced by the cost of emissions, is at the margin.

The importance of allocative efficiency will also grow in a period when the achievement of emissions reductions depends to a significant degree on switching fuels and on technology shifts which embody or translate into major consumer choices. To take the household sector as an important example, most low emissions scenarios depend on households engaging with a variety of technical alternatives, including condensing boilers, high levels of insulation, local or decentralised renewables, electric-powered underground heat pumps, as well as simple traditional choices such as electricity or gas for cooking.

In a context of reducing emissions in order to limit the potential damage of climate change, this means that costs or price for emissions, and indeed cost structures as a whole, should be factored into the price of a fuel use on a consistent basis that reflects actual production and emissions costs. As far as residential and domestic consumers this patently does not happen, and cannot happen, since the effect of load profiling simply averages the fuel costs charged to domestic consumers according to a load profile assumed for domestic consumers as a class. In consequence it ignores the very substantial variations in marginal generation costs that occur according to time of day and time of year, which will be accentuated very dramatically as electricity generation moves from a mainly fossil based system to a mainly carbon-free system.

This limitation to allocative efficiency could be profoundly important in settling the economics of alternative domestic heating systems, since heating load is intrinsically susceptible to coincidence with peak usage, and price signals will only lead to consumers making the best “low emission” choices if they face carefully constructed time differentiated tariffs, which in turn will require more complex but technically straightforward time of day metering. This analysis will apply to some degree even in much smaller but still important choices such as use of gas or electricity for cooking.

5.5. Unfair competition

General concern over the competitiveness of the market arose in the 1990s as a result of the highly concentrated structure of generation. This concern, at least in respect of wholesale markets, was to some extent dissipated by changes in ownership of plant, divestment, and much reduced indices of industry concentration. Even so there are residual questions over the vertically integrated structures that have developed.

A more subtle source of unfair competition has been identified, inter alia by the late Dennis Anderson[7]. In a predominantly fossil fuel based system it is fossil prices, whether or including any carbon price element, that will continue to set market prices for many years to come. This means that the variance in the net present value of investment in fossil plant is comparatively small, since changes in fuel or carbon prices simply get passed through into the wholesale price. Fossil plant investment is therefore far less exposed to the risk around fuel and carbon prices than low or zero carbon investment, even though the corresponding risk, viewed either as a social cost or in terms of consumer prices, may be much higher. This creates a degree of unfair competition, tilting the playing field against low carbon investment, which is intrinsic to a gas and coal dominated generation market. In principle at least this is a real barrier to entry.

5.6. Parties capable of contracting

Reliance on markets assumes that commercial incentives will suffice to induce investment. One of the biggest issues for potential investors in power generation is the long life and highly specific and non-mobile nature of their asset. If the wholesale market does not support "merchant" investment, essentially speculative against future prices over several decades, then such investment will depend on long term contracts. However the current structure of the sector does not provide reliable counter parties able to enter into such contracts, because this is not consistent with the competitive framework.

6. Conclusions

1. General case for review. We need to recognise that the electricity market is, and will remain a complex administrative structure, whose main features have been determined by a mixture of factors, including the corporate interests of major players. The extent to which its operations conform to the economist's theoretical concept of a perfect market that induces efficient and optimal behaviour from participants is limited by a large number of factors. These include not only traditional competition policy concerns over market concentration but also the technical constructs that underlie wholesale pricing and the arbitrary administrative conveniences that underpin retail sales. It is therefore legitimate to question whether the market as currently constructed is actually operating in the public interest, and particularly whether it will continue to remain "fit for purpose" in a period when emissions and climate change policy is growing rapidly in importance on the policy agenda.

[7] Dennis Anderson, Policies for a Low Carbon UK Energy System, August 2007, Findings of a Study for the IPPR

2. Adequacy of wholesale market and operational arrangements in new low carbon environment. A major function of an effective market is to provide a secure basis for investment with a level playing field on which alternative types of investment obtain equal treatment without undue discrimination. It is clear that the existing wholesale market mechanism, BETTA/ NETA as the successor to the Pool, has as its primary drivers the need for load following and for optimising the variable costs of fossil fuel plant, and that its design reflects the technical characteristics of fossil plant. It is not therefore surprising that the mechanism should have been accused of discrimination against non-fossil plant. More importantly it is clear that a very different mechanism is likely to be needed to cope with a power sector market from which fossil generation has been, for all practical purposes, eliminated.

3. Adequacy of capacity incentives. There remain very considerable doubts over the adequacy of the incentives to create new capacity, even if the particular concerns to get new low carbon investment are put aside. These doubts relate to the adequacy of the market mechanism to reward capacity, and would exist quite independently of CO2 emissions policy issues.

4. EU ETS. To date the EU ETS is the "only show in town" that purports to provide a mechanism for internalising the cost of emissions in the electricity sector. However there are a number of reasons to doubt its adequacy as a primary instrument for meeting UK policy targets. At the very least its operation, its impact on electricity markets, and its credibility in the context of low carbon investment, need to be subject to careful review.

5. Bias to fossil fuel and barrier to low carbon entry. While generation remains dominated by fossil fuel, it is fossil costs, including the costs of their associated CO2 emissions, that dominate the construction of prices. The market therefore limits the risk of fossil investment, creating a significant bias towards fossil plant. The wider variances associated with the net present value of low carbon plant partly offset the potential economic advantage. In effect the market inertia of a fossil dominated system constitutes a real barrier to entry.

6. Obligation to supply. There is no entity currently charged with the obligation to supply. Nor is there any obvious candidate on whom such an obligation could be put without major effects on the nature of the market. If therefore it becomes apparent that reliance on the market is failing to deliver adequate levels of low carbon capacity, then the only fall-back is government intervention in some form.

7. Smart metering and allocative efficiency. The absence of adequate cost reflective retail pricing militates against the efficient development of a low carbon future in the household sector. The use of load profiles, introduced, paradoxically, because waiting for more sophisticated systems might have delayed the introduction of retail competition, provides average cost messages that are not appropriate to the circumstances of individual consumers, and do not provide the right signals for the choices that will need to be made. This will clearly need to be changed.

8. Impact of a hydrogen or battery-electric economy, and of decentralised power generation options. In the longer term, the effect of major technical shifts in other major sectors of energy use is another factor that potentially transforms electricity markets. The effects are inherently hard to predict, but the injection of additional electricity demand associated

with a hydrogen or electric vehicle-battery economy would transform the economic character of the market, essentially by creating a form of electricity storage through these alternative vectors. This would improve the economics of both nuclear and renewable sources. It would also increase the importance of price signals for productive and allocative efficiency.

9. The Way Forward. Some though not all of the market weaknesses identified in this paper are clearly susceptible to reform and innovation. Operational bias against non-fossil plant may be a matter of simple rule changes; incentives for capacity can be created with or without CO2 targets; smart metering requires major investment and changes to the retail market, but is clearly feasible. However these, as well as the potentially more difficult issues associated with the EU ETS, are non-trivial reforms and will be time-consuming to pursue. Reliance on markets as the sole or primary instrument of change therefore risks serious delay as market structures are "adjusted", without any absolute confidence that all the market barriers to low carbon entry can be overcome. The urgency of progressing low carbon electricity suggests that anticipated investment in electricity generation needs to be closely monitored, starting immediately, with a view to additional measures if it becomes clear that market signals are not delivering solutions on the scale that is required.