Governance and disruptive energy system change

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Abstract:

This paper explores the biases towards the conventional energy system currently in place in GB; it looks at potentially destabilising factors at work in the GB energy system; it looks at disruptive influences at work in the wider energy system; and it asks whether those wider factors are sufficient to force change in the GB energy system.

1. Introduction

The electricity system in Britain is entering an interesting phase, where there appears to be some possibilities for change in its structure and in its characteristics, and therefore in its practices. There is, however, no certainty of that change given a current strong alignment between the Coalition Government, Great Britain's (GB) Energy Regulator, Ofgem, and the big incumbent companies which dominate generation and supply. Nevertheless, even if change occurs driven by mainly external factors – which seems likely and which this paper tries to explain – its speed is likely to be constrained because of the GB market liberal paradigm and its associated economic and political institutions (Lockwood et al, 2013a and 2013b; Mitchell et al, 2014).

This paper describes the current situation in the GB electricity system; attempts to explain what new factors are working on the GB electricity system; explores wider disruptive influences within electricity systems elsewhere in the world; and wonders if these new factors will be strong enough to disrupt GB?

2. The current GB electricity system – large, centralised and dominated by incumbents

The British electricity system became increasingly centralised with the creation of the State monopoly, the Central Electricity Generating Board (CEGB) in 1947. The privatisation of the electricity supply industry (ESI) in 1990 established a number of large companies in Great Britain from the monopoly Central Electricity Generating Board: 5 generators, 2 transmission and 14 distribution companies (regional electricity companies (RECs)). The market, infrastructure and regulatory structures set in place at this time reflected the characteristics and operation requirements of this supply focused, centralised energy system made up of large scale, often inflexible, power plants (Surrey et al, 1996; Mitchell, 2010).

At the time of privatisation of the ESI, there was an intense campaign to raise share ownership across society. A key political design requirement of this was that these investors would not lose money from their investments, and preferably could make money. As a result, the design of the industries (i.e. gas and electricity) was set up so that they could not fail i.e. with limited risk, and these shareholders could not lose their money (Surrey et al 1996). The corollary of this has been the difficulty of stimulating any basic change to the structure, rules, incentives and practices of the industry set up at that time, despite vast change in understanding the needs of climate change mitigation, technological change and expectations by customers.

The networks were set up as regulated monopolies – both at the transmission levels and at the distribution level – where regional electricity companies initially combined distribution and supply functions until they were turned into separate distribution network operators (DN0s) and suppliers when full retail competition came in 1998. A central governance aspect of privatisation was the implementation of rate of return regulation for the network companies. The companies had their assets valued at privatisation (known as the regulatory asset base (RAB) or regulated asset valuation (RAV)) and they were allowed to make a return on that asset base. Any expenditure on capital assets since that time has been added to that RAB. This set up the incentive to increase their RAB, and despite changes to this (RPI-X to RIIO) (Ofgem, 2010b and 2013b), the fundamental incentive driver for the network companies remains on capital asset expansion and continues to be a fundamental driver to their behaviour (Lockwood 2014). Reducing total energy demand would reduce the units of energy moving through the systems and this would both reduce their per kWh income but also mean that capital expenditure would shrink in line with the infrastructural needs of lower consumption, neither of which is in the fundamental interest of the network companies.

Customers were inherited by suppliers from these regional electricity companies when markets were opened to retail competition in 1990, becoming fully competitive in 1998. It is a link between these customers and the ex Monopoly companies which has proven so hard to break. A new entrant finds it very hard to make money and prosper if it cannot get hold of enough customers to make money from, or if it is very expensive to obtain those customers.

The UK energy regulator, Ofgem, oversees the UK gas and electricity markets and network infrastructure. As a direct result of the original design of the industry at privatisation, the generation, network companies and supply companies have merged over time to become dominant, 'Big 6' vertically integrated energy companies. Despite legislative change to regulation (i.e. Utilities Act in 2000 and the Energy Act 2013), the dominance of a few supply companies has remained, with independent suppliers now providing 7.5% of electricity, double from 2012 (DECC, 2014a; Cornwall Energy, 2014).

The markets sell and buy electricity on a marginal cost basis, which means that for every hour, or half an hour, the most expensive generation sets the price of electricity for the half hour. This is the source of profit[1] by the companies which generate mainly from fossil fuel or nuclear power. These markets are about supply (selling and buying) and have rarely included rules and incentives which allow the demand side to bid in – whereby the bidders are paid to not buy

[1] This paper will not enter into the discussion about what an appropriate return is, and the difference between an appropriate return and inappropriate profit or rent

electricity for an hour or a half hour, thereby reducing the marginal cost price paid for all supply in that half hour.

Practice change (including a refocusing to the demand side) and new entrants has been limited because the electricity system incentives or ways to make money (or recovery paradigm as Edison Electric call it (Edison Electric 2014)) still remain based on sales; because it has been hard until recently to get customers to switch (see liquidity below) and therefore difficult for new companies to develop new businesses (since they need customers to sell to); because transaction costs of entering the energy industry and markets remain high and risky (see market below); because the network codes benefitted incumbent generators and because they are very difficult to change (see codes and licences below).

The conventional electricity utility (certainly in the British sense and discussed in this paper) is therefore a large, usually ex State monopoly incumbent company; with millions of passive customers that it has limited connection with; which sees itself as supply orientated; and dominant because of its size in the market. Its business model is to maintain its market share, or preferably to increase it so: tending to do what they have always done; not supporting innovation which may open up the market to challengers; nor encouraging its customers to be active or connected; and to, where possible, provide high dividends to shareholders to reduce the risk of hostile takeover. The conventional utility model energy system is one made up of these companies across generation, networks and supply which act together in similar ways.

3. Self-reinforcing Governance

Electricity systems are in the process of change in certain places, discussed below. However, in Britain the governance of the electricity system institutions and their rules and incentives benefit the incumbents. There is a web of inter-related bias towards, and maintaining, the conventional utility model (Baker et al, 2009 and 2010). The next section describes the current policy landscape in Britain. This section describes some key material areas which support incumbents: electricity market design and rules; poor liquidity of customers and trading; vertical integration which makes the electricity price opaque, and reduces liquidity of trading; retail market regulation; a Code governance which is not fit for purpose; and a supplier hub model which does not recognise embedded benefits. When taken with the section above which explains how network governance encourages sales rather than efficiency, and the way that privatisation was set up to reduce risk of failure for incumbents, it becomes possible to understand why so little practice change has occurred in Britain.

Electricity Market Rules

The Pool was the electricity market in place for England and Wales from 1990-2001; the New Electricity Trading Arrangements (NETA) from 2001-2006; the British Electricity Trading and Transmission Arrangements for England, Wales and Scotland since 2006. Ofgem is currently undertaking a review of Future Electricity Trading Arrangements (FETA).

This is not the place to explain how electricity markets work (please see Sioshansi 2008a, 2008b, 2013). In brief, in a 'generic' electricity market Pool, generators and suppliers (sometimes known as retailers in the US) enter their bids for their generation and their demand (i.e. what they want to buy) for some time ahead. The System operator then 'stacks' the offers of generation i.e. the lowest offer for generation is taken first and then the next cheapest offer is taken and so on until supply matches demand for a certain period of time (half an hour in Britain). The final (marginal) generation offer that matches demand becomes the electricity price for that half hour, known as the Pool price. Suppliers were price takers for each half an hour – in other words, they have no choice over the price paid – it was always the Pool price, although that changes over the day and the year.

In England and Wales (E &W), National Power and PowerGen were the only 2 privatised generators from 1990 until 1996. This was not the preferred option but was the result of the unexpected inability to privatise the nuclear portion of the electricity supply industry in 1990 (Surrey, ed, 1996). Once it became clear that the nuclear portion of the Electricity Supply Industry could not be privatised and was pulled from the privatisation, it was too late to redesign privatisation. With hindsight, the choice to not hold up the privatisation vesting date further was a key decision for the future of energy in GB.

Because of the limited number of (large, centralised) power stations in GB; because the costs of each power plant were roughly known (because knowledge moved with individuals from the monopoly company CEGB into the new privatised companies); because of the limited number of generators (two in E and W); and because of the knowledge of customer demand (again from monopoly days) it was possible to know the merit order of the power plants for most half hours. This allowed the two companies to roughly know the marginal Pool price, and therefore the revenue they would make. It would then not take too much effort on the part of the generators to bid in a slightly more expensive plant to raise the marginal Pool price – for the benefit of both generators but not of customers. Thus, even without collusion, the E&W Pool of 1990-2001 was not a successful design.

Given this situation, the Utilities Act (2000) was implemented to overcome what was seen as a lack of competitiveness and high prices in the electricity 'Pool' and a general lack of connection with consumers and their wishes. It is important to note though that 'the Pool' design is the most widely used form of electricity market throughout the world (Sioshansi, 2008a and b, and 2013). Details matter, and if set up correctly can have considerable benefits over its successor: the bilateral NETA/BETTA markets. Pools can be transparent and have less risk for new entrants and smaller players. The primary reason why the British Pool did not work was because of only having two players, and this was due to the design (i.e. institutions, rules and incentives) of privatisation.

Within the successor electricity market design of NETA/BETTA, generators and buyers inform the balancing mechanism market and system operator of their contracted position and how different they are from it. They will then have to match their contracted position through a balancing mechanism (BM). Depending on available supply and demand, these balancing prices can be very expensive, and it is therefore difficult for independent or small generators, particularly with intermittent generation, to take on these risks. Those risks have also encouraged vertical integration of generation and supply companies, discussed below.

The BM 'balances' the market – and it is only in this market that demand side bids operate. In total, the BM makes up about 3% of the electricity volume. It is therefore a very opaque or non-transparent market and, given the lack of liquidity in future markets (discussed below), it is difficult to know what the 'real' electricity price is for the majority of electricity traded. A new entrant, or independent, supplier which would like to buy the amount of electricity they need from a futures market cannot be certain they will not paying too high a price because of lack of liquidity. Alternatively, they could buy bilaterally from a generator but, again, the latter may have more market power than they do and so be in a position to ask too high a price. Finally, they could buy through the BM, but again they cannot be sure they will not be paying too much.

All companies over a certain size which wish to buy and sell electricity either have to become party to various Codes, which includes certain IT systems and costs (see below), so that they can sell through the BM, or they have to sell their generation through a consolidator (an aggregator, a broker) which is signed up to the Code, and which makes their money via charges to the generator. It takes about a year to get the various Licenses and memberships in order before a company is able to sell something, and that is if they are able to access enough customer to make their business viable.

This opacity of electricity price, penal balancing payments, market power of incumbents, start-up costs and transaction costs, and general lack of liquidity makes it very difficult for new entrants, particularly for variable power generators. Moreover, the demand side is of minimal importance.

Liquidity

Liquidity issues relate to two main areas, and both are being dealt with (or not) via first an Energy Supply Probe in 2008 (Ofgem, 2008) and then ongoing Retail Market Review which began in 2010 (RMR, Ofgem, 2010a and 2013a). The first area of concern relates to not having enough transparent trades within electricity markets, both intraday and forward trading, to enable sufficient liquidity to (i) minimise the risk of ending up without enough physical electricity or paying too high a price, and also (ii) to illuminate a transparent electricity price and trend. The second area relates, according to Ofgem's reading of the problem, to customers and the degree to which they 'switch' suppliers or the degree to which they 'stick' with their suppliers.

Sticky Customers

Good liquidity of customers is important for two reasons (1) if new entrants cannot access customers, they cannot provide new services; and (2) if energy companies expect to retain their customers, come what may, they can make more profit out of them than is warranted. From the suppliers point of view: sticky customers are good because: (i) they are a dimension which helps the suppliers to understand how much energy they are going to sell and therefore what they have to do to remain in balance in the electricity markets; (ii) if customers 'stick' they don't interfere with the vertical integration (VI) balance between supply and demand (see below); and (iii) energy companies are able to worry less about competition with other suppliers or retaining their market share. For all of these reasons, there is little incentive on suppliers to educate their customers to the possibilities of alternative tariffs or reducing demand.

The ongoing RMR has come to the view, stated baldly (Ofgem 2013a) that customers don't understand tariffs, and the differences between them, and so they don't switch. Ofgem said they would regulate and/or cap the number of tariffs on offer. It is not clear what the extra cost of this is – but to the degree that it introduces cost, it becomes more complex and more difficult for new entrants to enter. Moreover, it is also unclear what the benefits are to customers because it is not so much the number of tariffs which is the problem but the difficulty in comparing them. Regulating comparison sites would seem to be a vital aspect of market liquidity but as yet this does not occur. Electricity is the same product at the point of use, although very different in the ways it is produced. If tariffs and bills do not show this differentiation between suppliers, then customers have limited means of understanding what is different about the different tariffs, and therefore whether they would like, or benefit from, a move. Another solution is also therefore greater disaggregation of costs in bills so that customers can understand how the bill is made up and what the differences are.

Liquidity in intraday and forward trading

Essentially there are three basic concerns about lack of liquidity in traded markets. One is about the transparency of prices (whether electricity or gas, wholesale and gas) and whether the markets reveal the 'real' price. The second concern is at the *level* of prices, and whether they are either artificially high (as a result of internal selling from the vertically integrated generation arm to the supply arm, see below) or that they are higher than they might be were there greater competition and liquidity in the electricity markets. Ensuring transparency of prices is likely to help with the level of prices (through increasing competition and liquidity). The third concern is that the transaction costs and risks are so great as to exclude new entrants which might offer better customer services.

All generators have to sell electricity in 'real time' when the physical generation is linked with the technical operating requirements of the network. Countries with actively traded electricity tend to have a real time market; multiple forward markets (ie markets which sell electricity at any point in the future i.e. for a day ahead, a week, month, year, 2 years ahead etc); and intraday markets.

These forward markets can either by physically based – meaning that their bids and sales end up being related to physical electricity – or they can be financially based – which means that they are essentially financial instruments to hedge the price of the physical electricity that generators and suppliers have bought and sold. These financial instruments do not finally trade out to physical electricity but to money lost or gained. These forward markets can be traded in directly from a company's trading arm (which will have paid to be a member of the market) or they can be accessed via a platform (which the company will also have paid to access). A company like Bloomberg has a platform through which electricity trades can be made in many different markets around the world, whether physical or financial. Transaction costs can therefore be a problem for new or small companies.

The UK's Balancing Mechanism (BM) is where only the balancing portion of electricity is traded. In general, buying and selling of electricity takes place between two parties. The generator or buyer only has to tell the BM market operator (Elexon) what their contracted agreement is and what they want physically to buy and sell in the BM to get themselves in balance with that agreement. They also have to tell National Grid (the system operator) what their actual output is going to be at gate closure (just before real time) relative to that contracted agreement.

Generators can sell into the future and buyers can buy ahead. Gradually time moves on to catch up with these forward trades, and the BM market operator balances all of the contracts for selling and buying electricity in one particular period of time – whether they were originally traded for a day ahead or two years ahead. Buyers and sellers of electricity need to make sure that whatever contracted position they have made (in whatever futures market and/or with whatever bilateral contracts) 'unwinds' in such a way that they are in balance (ie buying and selling what they are contracted to do). It is therefore important that markets are 'liquid' meaning that there is enough electricity for sale for different time periods and in different amounts ('clip sizes') to enable the buyers and sellers to match their needs.

The needs of different generators will differ. Generators of variable[2] power require liquid markets far more than generators of firm[3] power because they are more uncertain about what their actual output will be at any one time. Smaller generators need access to smaller 'clip sizes'.

In some ways, limited liquidity works to the advantage of incumbents because it adds risk for potential new entrants. However, for fossil generators in a Pool market with increasing amounts of low marginal cost carbon and / or zero marginal cost variable power, they have to ensure that they do not find themselves too expensive for a particular time period.

Vertical Integration – bad for customers, new entrants and innovation

The rules of the bilateral electricity market (NETA and BETTA) encouraged the vertical integration (VI) of generation and supply companies (Rutledge, 2012). This was a response to mitigate the market risk of the bilateral electricity market and the potential high costs of being out of balance. Broadly this incentivises VI: meaning that customer demand of a supplier is matched to the generation owned by another subsidiary of the same parent company. The VI generator sells direct to the VI supplier – at an unknown price – and this also reduces liquidity in the market. Given that the energy suppliers do not want to lose market share, this means, at best, that (1) there is little (or no) incentive on the Big 6 to encourage their customers to be more engaged and proactive about their energy use. Arguably, it is positively not in their interest to get customers interested in their energy use in case those customers then leave them; and (2) they will not want their customers to use less energy partly because they want to sell as much as they can (ie maximise market share) but also because if they do not sell all their generation output to their customers, then they have to find other customers to use their generation capabilities and this will cost money[4].

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[2] meaning that the output from the power plants changes depending on weather conditions and cannot be counted on to be dispatched when the system operator wants it

[3] Power is known as firm if it can be dispatched when the system operator wants it

[4] As concerns about this have risen during 2013/2014, the large energy companies have voluntarily agreed to sell via day ahead markets – thereby enabling them to argue that they do not sell directly from the VI generator to the VI supplier. This is a complex area and not discussed further.

This wish to match VI customer demand and supply has a number of knock-on effects. New entrant energy service companies (ESCOs) (whether generators, suppliers etc) can survive to the degree that they are able to attract/access customers to sell their products to. If an ESCO cannot access enough customers then they are unable to make enough money to survive as a business. Enabling access to customers is therefore vital, hence Ofgem's focus on retail market reform and 'switching' (see liquidity case study above). Thus, in a situation where all the large energy companies want to maximise their market share and want to match their generation to supply, there is a strong momentum to maintain the current system as it is, including keeping customers.

Interestingly, some of the smaller energy suppliers have developed new semi-VI business models as a way to get round this conundrum. Good Energy, for example, has tried to match generation to its customer demand but rather than own the generation they are contracting with 'prosumers' or small, independent generators to buy their energy. GE now contracts with about 85% of the household, on-site photovoltaic producers. This also means that they have incentives to encourage a different type of customers. They want connected, engaged customers who both proactively 'switch' to them but who also think about where their energy is coming from. They provide newsletters and recently have offered a bond issue to access finance for investment in generation, which was oversubscribed within days. Even so, all the new entrant suppliers together only supply about 7.5% of the electricity market (DECC 2014a; Ofgem 2014a and 2014b).

Codes and Licenses - Not Fit for Purpose

All electricity and gas actors sign up to Codes – there are 7 in all for electricity and generally electricity participants sign up to all of them. Uniform Network Code (UNC) is the Code users of the gas system are obliged to sign it. Codes and Licenses are very complex. An illumination of this for electricity is: the Grid Code which National Grid and the users of the Transmission network are required to comply with; the Connection and Use of System Charges (CUSC) is the framework for charging and connection to, and use of National Grids transmission system. The System Operator and Transmission Owner Code (STC) is the Code which governs the relationship between National Grid as a private company with its own incentives, and its System Operator (SO) arm which should act in the interests of the system. The Balancing and Settle Code (BSC) oversees the rules of the market and the costs of day to day running of the transmission system. The BSC therefore interlinks with the STC because the BM works out how much has to be paid to keep the transmission system balanced and operating, and what the rules are for charging those payments. Ofgem then sets the incentives on the SO to manage the STC and BSC rules which are intended to incentivise the SO to operate the Grid efficiently. The Codes and Ofgem are therefore very interlinked.

The Codes are the basis of the rules and incentives of all aspects of the energy system. Each code sets out the legally required behaviour within the area the Code is responsible for. In addition, actors require a License (for example, to operate, to supply etc) which tends to be more linked to general policy. Licenses require actors to sign up to a Code, and the Code sets out the detail of the behaviour. License and Codes are therefore entirely linked although the hierarchy of the two is unclear. As a right of joining a Code, for example the BSC, the signaturee has the right to change the Code via a Process set out in the Code, known as raising a Modification. This is known as a living rule. In effect, the incumbents are responsible for the operation of the network or the market (whichever Code) and this de facto enables incumbents to maintain their preferred rules and incentives.

At best, the Codes are fit for purpose for trivial change that few have an interest in. However, the Codes are not fit for purpose for significant changes because new modifications can be continually added thereby frustrating changes. A Code Governance Review in 2008 (Ofgem, 2008) concluded that Codes were poor at enabling change. As a result of the Code Governance Review, Ofgem can now initiate a Significant Code Review (SCR) within a specific Code. While the SCR is open, other Code members cannot initiate / raise modifications. Project TransmiT was, for example, a SCR (Baker et al 2011; Mitchell et al 2011a). Ofgem can raise a SCR but they cannot be sure they will get the outcome they want. Three SCRs have occurred in relation to transmission charging issues but none have led to change. Thus, the process of change within the Codes is very slow and complex. Smaller companies have greater difficulties in being able to afford to keep an eye on all the Modifications to the Codes.

The supplier hub model – excludes embedded generation

The GB electricity and gas system was very distributed until 1947 when all companies were nationalised into the CEGB or the Gas Board. Nuclear power and large coal electricity plants dominated the electricity supply industry for the next 40 or so years; and coal was the main source of gas until the 1960s. The electricity system was made up of a very few electricity power plants which injected generation into the transmission grid and then distributed it in one direction to customers via the distribution network. At privatisation of gas in 1986 and electricity in 1990, a supplier hub model was introduced whereby the costs of transmitting, distributing and balancing the system were paid for by customers on their bills and then passed back to the relevant company by the distributor / supplier.

However, any distributed gas or electricity generation injected into the distribution networks was considered to be 'negative demand'. This is still how embedded generation (and now embedded gas) is thought of in relation to the pricing of energy. For example, if a supplier needs 100 MWh of electricity in any one half hour, and has contracted for 10 MWh of Embedded Generation, they will buy 90 MWh via the electricity market. Embedded generation avoids paying various costs and these are known as embedded benefits yet all embedded benefits flow to the supplier rather than to the embedded generator. This is because the value of the embedded generation is not in the supplier hub model. Moreover, customers should not have to pay the same cost for an embedded kWh as a transmitted one, yet there is no differentiation in bills from distributed versus centralised energy.

It has taken years of arguments between Ofgem, generators and suppliers about this but the division of embedded benefits is still not 'institutionalised' in regulation. It is now accepted that a supplier should negotiate with generators so that the latter receives a division of the embedded benefits. Some smaller suppliers are absolutely fair about this but there is no set agreement and the independent generators are in a weak position vis a vis gaining a contract from a large supplier.

4. Current Energy Policy in Britain – continuing to entrench the incumbent position

The current governance system in Britain provides a web which supports incumbents. Falling peak prices as a result of variable power or demand side bidding are occurring in some electricity markets thereby affecting utility company profits, and potentially presaging disruption – discussed in the next section. However, this is not occurring in Britain.

Britain is just coming to the end of a four year energy policy period focussed on Electricity Market Reform (EMR) (DECC 2010; DECC 2014b). EMR is made up of four mechanisms: a carbon price support; contract for differences (CfD) for low carbon technologies (which will segue the renewable obligation payments over to Cfds but also provide CfDs for nuclear power, carbon capture and storage etc); a capacity mechanism and emission performance standards. It has been argued that the initial point of these mechanisms was to make the price of electricity in Britain so expensive that it would be possible for the GB Government to say that nuclear power could be developed in the UK without State support (Mitchell et al 2011). EMR has been one long, depressing saga in the history of UK energy policy decision-making and will not be repeated here (see Energy and Climate Change Select Committee Reports HOC, 2012; Mitchell et al 2011b; Mitchell and Woodman, 2012; Mitchell, 2013a and 2013b).

There are four points which it is important to recognise:

- Most of the energy industry in Britain and the energy policy commentators, for different reasons and with the exception of EDF the nuclear company, have been opposed to EMR and it has been forced through by Government. Arguments against EMR have been made but this have made no headway against the broad thrust of the policy.
- The GB energy policy decision-makers in the Department of Energy and Climate Change (DECC) have been so focussed on implementing the very complex details of EMR that they did not take notice of what was happening elsewhere in the world with respect to consumer drivers, energy technology development, falling renewable electricity costs, changing business models and energy system operation and management.
- It can be argued that the Regulator, whose Duties do include looking after the interests of customers (including future customers) has not looked after those interests from a number of perspective; and
- While the incumbents which have been opposed to EMR have not succeeded in blocking nuclear power, they have managed to reduce risk for themselves within EMR by forcing the Government to have a counterparty company for contracts (which essentially takes the risk) and to have a market wide capacity mechanism – both of which was not the original intention of Government and latter of which benefits incumbents

As they come to the end of the EMR policy cycle, and the final details are being put in place to enable EMR implementation (DECC, 2014b), these decision-makers in Government and in the Regulator are being forced from evidence of practice change to realise that a huge change has occurred since 2010, when EMR began.

5. Electricity System Disruption

Electricity systems in Europe were, very broadly, privatised in the 1990's – albeit with very different structures. The 50 States which make up the United States of America (USA) has also seen varying degrees of privatisation and liberalisation over the last 20 or so years. Most of these countries or States have had sustainable[5] energy policies in place for much of that time – the goal of which has been, again broadly, to reduce pollution for either clean air or climate change goals. The outcomes of these policies have been marginal to the practice of those electricity systems, except within a few countries: Denmark, Germany and California[6]. In other words, most systems have continued to be operated and managed in similar ways (despite some technology change, usually from increased percentages of renewable electricity); by

[5] Definition not discussed here

[6] To be discussed at workshop

companies with similar business models; selling to customers, who continue to have the same relationships to their energy use.

However, a few countries which have sufficient variable power renewable electricity or have incorporated demand side response into their electricity markets have moved beyond this model of operation (or are hoping to move beyond this model eg Zibelman, 2014), and they are opening up space in which disruption may occur in their own electricity systems and which may have a ripple effect to other electricity systems. Disruption is used in this paper to describe a rapid change in the characteristics of an electricity system, which has its own momentum (ie not just dependent on policies) and which leads to different operating and management processes, which in turn enables different social, economic and technical outcomes. In other words, systems begin to be operated and managed in different ways; become made up of companies or social enterprises with different business models; have customers who sometimes have different relationships to their energy use; have markets which include value beyond energy to include different flexible operating characteristics, such as fast ramping rates etc, storage as well as demand side bidding; and have sufficiently different technologies – whether for supply, demand or operation - to alter economics and involvement. But at root, this disruption has to existentially, significantly negatively threaten the conventional utility model, as opposed to transformation (Stirling, 2014) which may occur without disruption[7].

Fossil fuels have positive marginal costs, mainly made up of fuel costs. These marginal costs differ between power plants and so a hierarchy of plants develops in conventional electricity systems with the most expensive only being used very rarely throughout the year. Variable power renewable energy has zero marginal costs and generates differing amounts depending on the weather. This means that within conventional electricity market rules, zero marginal cost electricity generation is bought first, thereby shifting the supply curve over to the right thereby pushing out increasing amounts of fossil fuel generation as increasing amounts of renewable generation occurs. Not only is fossil fuel generation pushed out of the market, but at peak times it loses its expected high rates of payment for their electricity[8]. The combination of this is that fossil fuel generation is becoming less profitable, if not positively unprofitable (Aneiro, 2014; Atherton, 2014; Barclays, 2014; Citi Research 2013 and 2014a and 2014b; Deloitte, 2013; Deutsche Bank, 2013; EEI, 2013; Evans-Pritchard, 2014a and 2014b; Ernst and Young, 2013; Hastings-Simon, 2014; Lovins, 2014; Platt et al, 2014; RWE, 2014; JPMorgan, 2013; Moody's, 2012; The Economist, 2013; Bloomberg, 2013; Nomura, 2012, Pollitt and Nillesen, 2014; PwC, 2013; Citibank 2014; UBS, 2013, 2014a and 2014b; Wile, 2014).

[7] To be discussed at workshop

[8] Electricity prices can become negative but this is to do constraints on the system and should be able to be avoided.

Falling revenues and peak prices can also occur in countries or States which have demand side bidding but not necessarily high levels of renewables within the electricity markets. An example of this is in the US, which has reduced peak prices by an average of 6% in 2013 (Mitchell, 2014) and PJM recorded a fall of 90% at one particular peak time (RAP, 2014). However, a more flexible demand side also helps to balance the energy system. Conventional fossil generation supply is reasonably flexible and has historically fitted around the demand side – which has been seen as inflexible. As a larger percentage of supply comes from variable power, then there is less certainty of supply and a more flexible demand side makes system balancing easier. Not only does it make sense to reduce total energy use, or load shift away from peaks from both an infrastructure and price point of view, it is also helpful operationally.

If zero marginal cost variable power is reducing conventional utility profits, then adding in demand side flexibility will reduce them even further. So far, these two factors are happening and existentially affecting the conventional utility model but they are not as yet happening anywhere together, with the possible exception of California[9].

The liberalisation process across Europe separated production, transmission and supply with the objective of enabling new market actors leading to greater competition and in theory reducing costs for the consumer. However, this process, in the generating sector, has been until recently very gradual. According to statistics from Eurostat, in the 26 countries for which comparable data was available the largest electricity generator had on average 67% of the market in 2003, but this had only reduced to 59.4% by 2012 (Eurostat 2014).

The development of renewable energy is however, quickly reducing dominance of the major utilities in some markets. In Germany for example, there are over 1.4 million individual PV units (Cleantechnica 2014), and in terms of generating capacity the “big four” generators, Eon, RWE, Vattenfall and EnBW, had at the end of 2012 a combined installed capacity of 80 GW, less than 50% of the market (RWE 2014). At this time the installed capacity for Solar PV was 33 GW and wind was 31 GW (BP 2014), with big four owning just 5% of this capacity. However, this is not just a German story, large scale deployment of renewable, particularly solar PV has occurred across the EU, with deployment at the end of 2013 reaching nearly 80 GW (eg STA, 2014).

There are also a plethora of new companies entering the electricity and utility sphere, particularly in the field of IT (Neff, 2014; Grobart, 2014; Tesla, 2013). One of the most iconic in 2014 was the purchase for over $3 billion by Google of Nest, a smoke detector and thermostat

[9] To be discussed at workshop

company, started 4 years earlier by a former Apple designer (Kelion, 2014; NEST 2014a and 2014b; Warman, 2014; Winkler & Wakabayashi 2014). Google, is said to be interested in the creation of a “conscious home" (Carroll 2014). Many other companies, like Accenture, IBM, Cisco are now accelerating their involvement in the grid optimisation or network building space.

Potential future disruptive technologies

Energy storage is another area in which rapid changes are expected, in particular for batteries Bayer, 2013; Hoerner, 2013). Some of this is larger scale, with companies like Samsung now supplying large, 1MW, units (Grobart, 2014; Bradshaw, 2014). However, the area which is leading to the most excitement is on household level. The combination of rooftop solar PV and cheaper storage is seen by as the next big threat to the market and income of the utilities. Until recently, individual storage units were not seen as a viable option, but prices have fallen rapidly (from $500/kWh in 2013, to $360/kWh in 2014) and financial institution, such as UBS, are predicting further cuts, with prices as low as $100/kWh within 10 years. On this basis they assume the payback time will be as low as 6-8 years for a combined Electric Vehicle + solar + battery investment by 2020 – unsubsidised (UBS 2014a).

This accelerated expected decline in storage costs is a reflection of the confidence in the development of batteries for Electric Vehicles (EVs). Batteries are now ubiquitous and there is clear cross-over between the technology developments in the different sectors. It was the drive for lower costs for laptop batteries that accelerated falling prices in the EV sector (Barclays 2014). However, now it is EVs that are driving down storage costs. The most graphic example is the Tesla company, one of the world’s leading EV manufacturer, which announced in September 2014 that it will build a $5 billion ‘Giga factory’ that will double the global annual production of EV batteries and potentially half their production costs (Tesla, 2013).

Factors challenging the conventional utility model

As discussed above, a web of factors which bias towards the traditional utility model are still in place in Britain. Furthermore, the relationship between the Regulator, the conventional utility companies and Government appear to be aligned and reasonably content with this bias. In this sense, one might argue, that incumbents still hold the power in Britain, and challengers find it difficult to get much purchase. However, there are a number of factors which appear to be building up pressure on the incumbents and having an impact on this top-down, narrow energy policy decision-making world.

Household dissatisfaction and re-engagement with energy

This includes an increasing level of dissatisfaction from households and individuals with the current energy system, the cost of energy, mistrust in main suppliers and the regulation of the market (Ipsos Mori, 2013). This is leading to growing levels of switching from the Big 6 suppliers to independents, thereby increasing the potential for new entrants / challengers to be able to offer new services. At the same time, there is increasing consumer interest in taking control over their energy use, including steps to reduce demand and/or generate power at the building or community scale, which will create further momentum for change within the energy system, from the bottom up (Platt, 2014b)

In respect to the domestic market, there has been a gradually but consistent trend in switching away from the Big 6 suppliers to smaller independents, in response to concerns over price and trust, but most likely also influenced by ongoing media and political interest in these issues (see below). Recent analysis suggests that 7.5% of the market is now with independent suppliers and there has also been a doubling in the number of smaller suppliers to 14 since the beginning of 2012 (Cornwall Energy 2014; Consumer Futures, 2013 and 2014; Dolphin and Selim, 2014; DECC 2014a and 2014b). It is suggested that this growth in smaller suppliers is unlikely to be a temporary phenomenon and as such could lead to significant disruption and competition to the incumbents (Reidon 2014).

Since 2010 there has also been a significant uptake of PV from individuals leading to a rapid growth in the amount of distributed generation within the national energy system. By the end of the first quarter of 2014 there had been over 500 thousand small scale installations, i.e. under 4kW (DECC 2014c) and it is suggested that a target of installations on a million roofs by 2015 (STA 2014) might be achievable. This uptake has been driven by the introduction of a Feed-in Tariff and a dramatic fall in the price of PV and it is already suppressing energy demand on the transmission system and is expected to continue to do so (DECC 2014d). PV is therefore beginning to affect how electricity system traditionally operates and the incumbent's business models, as well as create a large number of new small investors within the system.

A number of other potentially disruptive technologies are also coming to market that will further enable individuals to become more active within the market, such as smart meters, smart appliances, thermostats and other controls; whilst other technologies are seeing significant cost reductions such as LED lighting and storage. These are expected to further increase the potential for action on the demand-side and may impact the conventional utility model. Many of these technologies are also being driven by global companies involved in the technology, internet, communication and appliance sectors, which will potentially create new types of competition within energy markets (Platt et al 2014).

The ability for action on the demand side from energy consumers is increasing and is expected to continue to do so, reflecting the availability of new technologies and services, and there increasing financial accessibility (DECC 2014d). There is also a growing interest in more collective approaches, including community energy based initiatives (DECC 2014e) as well as action from local authorities who are trying to make inroads into new energy services (DECC 2014d). Whilst as yet little has come of them, there is momentum behind them. They encompass millions of potential customers, which could be further taken away from the large utilities.

From a household and individual perspective we are therefore witnessing a convergence of consumer interest to take action, along with the means to do so - to reduce demand, respond to demand, or to generate electricity. This alignment reflects social and economic drivers in response to energy costs, as well as new technologies and falling technology costs. It is creating momentum for change within the energy system, from the bottom up that will increasingly disrupt existing utility models and the energy system more widely.

Political Responses and the CMA Investigation

A lightening rod for the growing unhappiness of individual consumers with the current energy system was Ed Miliband's (the Opposition Leader) speech to the Labour Party conference in 2013 – this is known as the reset speech (The Labour Party 2013). In the speech, he argued that the Regulator had to do more to look after the interests of customers and that the conventional energy companies had to justify their profits, putting forward the idea that both the Regulator and companies might be broken down and reformed. In his speech Miliband used energy prices to highlight his core message that while the economy might be improving individuals were still struggling to pay their bills. Therefore the energy issue was primarily a vehicle to get over a political message rather than an indication of the importance per se that he put upon the sector.

This speech, stimulated from the general dissatisfaction with large energy companies in Britain by society, had a number of knock on-effects: the Prime Minister became involved (Cameron, 2013); the Regulator attempted to explain how the energy companies made their profit (Ofgem 2014a); the Regulator and Office of Fair Trading carried out a review (Ofgem and OFT 2014) and finally, the Regulator has asked the Competition and Merger Authority (CMA, 2014) to undertake an investigation to see if uncompetitive practices are at work in the energy system in Britain.

This CMA investigation has a very broad remit and it has been the focus of many submissions from across the energy system arguing for a fundamental questioning of the assumptions behind the energy system in Britain, including the role and remit of the regulator (Mitchell et al, 2014b). It will not give its recommendations until after the 2014 General Election but the CMA has the ability to force far-reaching decisions on the industry. For example, it could force the breaking up of the incumbents; a new market mechanism; new Duties and roles for the Regulator and so on.

Media

Arguably the media has also played an important role in keeping energy in the front of mind of consumers as well as politicians. The apparent negative and consistent reporting on energy costs (HCECCC 2012) is likely to have had an impact on the incumbents, helping to encourage growing levels of switching towards independents, although it has also impacted wider policies, such as those designed to help reduce energy demand, so of which have been watered down by the current government. The peak in number of total switchers occurred in late 2013 after Milliband's speech (DECC, 2014c).

Elections in Britain – General and a Scottish Referendum

Britain has a general election in May 2014 when the current Conservative / Lib Dem coalition may be voted out of office. A Labour or a Labour / Lib Dem coalition is markedly more pro-environment than the Conservative Party. The previous Labour Government argued for the need for electricity market reform, although it was not in power for the policy details. A Scottish referendum is also being held on 18 September 2014 on whether Scotland should become a separate country. If this occurs then British and European politics will be deeply affected, and even if the Union is maintained, far greater powers of devolution are expected, but this is not discussed any further. The combination of these elections has meant that energy has held a highly important political place in Britain, at least since the reset speech.

Financial Analyses – the drip drip turning to a waterfall

Financial analyses of sectors (and their companies and technologies) for investment have routinely been undertaken for decades by the large financial houses and banks, such as Price Waterhouse Cooper (PwC); Citibank; UBS; Deutsche Bank; Morgan Stanley and so on. What has changed over the last year is a similar, overarching sentiment of where they see the energy system going: that disruption to the conventional utility model is coming and that conventional utility models are no longer fit for purpose (Aneiro, 2014; Atherton, 2014; Barclays, 2014; Citi Research 2014a and 2014b; Deloitte, 2013; Deutsche Bank, 2013; EEI, 2013; Evans-Pritchard, 2014a and 2014b; Ernst and Young, 2013; Hastings-Simon, 2014; The Economist, 2013; Bloomberg, 2013; Pollitt and Nillesen, 2014; PwC, 2013; Citibank 2014; UBS, 2014a and 2014b; Wile, 2014).

An example of this is a comparison of the PWC Global Power and Utilities Survey between 2012 and 2013 (PwC 2012 & 2013). The 2012 Big Issues were: Huge Demand Growth, Investment and Affordability, Clean Energy, Smart Energy, Company Strategies; whilst the 2012 Big Issues were: Transformation, Disruption, Technology and Supply. The 2013 survey highlights how supply is no longer a simple matter (because of the need for demand side technologies in systems with high proportions of variable power) and therefore do not recommend investing in conventional supply companies; they highlight the changes and disruption coming to energy and the importance of particular disruptive technologies. The 2013 Survey was based on 53 power and utility companies in 35 countries. 94% of these companies predict complete transformation or important changes to the power utility business model.

It is not that each financial report cited above is necessarily ‘right’, indeed there are differences in the numbers they use, and the predictions they make. More, the reports reflect the signs of change; and are important in signalling and validating the maturity of the arguments about the increasing importance of decentralisation and the increasing challenges paid to the centralised models. These cautious institutions have been recognising the consequences of the changes afoot globally. They have noted the disruption in different pockets around the world and they have put the possibilities of the separate social, economic and technological changes together. Over the last two years the view that there is structural change in the utility sector has consolidated in their reports. However, it is still unclear from their reports the range of new business models, actors and scales that will form the new sector - an area of significant opportunity as well as uncertainty – i.e. whether the large utility companies will survive or not.

In one sense, these financial analysts were open to change in the energy system. They have lived through the huge speed of change related to information technology; mobile phones / telecoms; print and media provision. They can see that the power sector is ripe for change given social concerns and the availability of new technologies. Now they can see the power of new service providers: airbnb and zopa etc. They can also accept that because change in energy has previously been slow, it does not mean that change has to be slow this time; nor does change have to be driven by some external crisis as the last crisis was (i.e. by the oil shocks of the 1970’s). Disruption may occur in the sense that fossil fuel power electricity plants will be in crisis and the fossil supply chain manufacturer’s share prices may drop and the current utility model may have to change but it is not a crisis in terms of security of supply or rising prices – as the past energy shocks were. Indeed this change should, through economies of integration and system, reduces costs rather than increase them.

The financial analysts credibility to the conventional alignment of pro market ideas, institutions and interests which make up the conventional bias of the utility sector in GB is the source of their importance. Other commentators (e.g. Mitchell et al, 2014) which have made the same points as the financial analysts do not have the financial analysts credibility. A whole series of quotes is provided in Annex 1 from these financial reports.

6. Discussion

Where does all of this take us? From an energy system perspective, it seems clear that the dominance of centralised energy systems has been broken. There is a slow but steady move from centralised to decentralised energy systems which results from a complex mix of social preference, technological ability, regulatory flexibility, political processes, and economic reward. That some countries, for example Britain, are more at the centralised rather than the decentralised end of this spectrum is due to the same but opposite set of complex inter-relating factors – regulatory inflexibility, a lack of economic reward, a top down determination to build nuclear and insufficient consumer drive, arising from political governance and institution issues (Lockwood et al, 2013a; Mitchell et al, 2014).

However, there are also factors in Britain which, whether they recognise it or not, are together creating an assault on that bias towards centralisation and the conventional utility model. Three important questions are: are the rules and regulations of a country which are biased towards the conventional utility model sufficient to withstand that assault and maintain that conventional utility model? Or will social, economic and technological change force change on the alignment of the Government, the Regulator and the traditional utility model? And will it be disruptive?

It seems that a tipping point has occurred within the financial analysis world but that there has not yet been a tipping point within *any* energy system[10]. Arguably, for example, German resistance has kicked in[11]. Certainly, disruption has occurred in Germany to the extent that the current utility model is under threat. However, even countries where limited practice change has occurred, are being affected to some degree because of what is going on elsewhere. This is certainly the case in GB. From a practice perspective, customer switching has become a first sign of change and an existential threat to large suppliers in GB. Whether this surge of

[10] To be discussed at workshop

[11] To be discussed at workshop; see also Lauber, 2014.

switching and / or customer re-engagement can be maintained will become clear over the next year or so.

The combination of this disruption in a few countries or US States around the world; the strength of arguments of the financial reports; the political elections, and heightened dissatisfaction of customers; the CMA Inquiry seems to point towards change in GB, and a potential weakening of the current alignment Government, Regulator and conventional utility models.

However, while a potential new alignment of ideas, institutions and interests is more visible in GB it has not *as yet* become powerful enough to alter the dominance of those ideas, institutions and interests which are biased towards the conventional utility model. Certainly, the institutions and their rules and incentives have not yet been fundamentally affected, and the ‘recovery paradigm’ has still not been affected, indeed, if anything, that has become more retrenched in favour of the traditional utility mode.

Annex 1

Deloitte	The more traditional business models that have served the electric power industry so well in the past simply may not be enough this time – the time for true innovation in the electricity sector may have arrived. By the application of insight and ingenuity, when the year 2020 comes, the successful electricity company may look very different from the electricity business as we know it today (Deloitte 2013).
Ernst and Young	Breaking with the past, on budgets with little elasticity, utilities have to wake up to the fact that they can no longer continue with business as usual (Ernest & Young 2013).
Citi Group	We expect a new business model to emerge with (i) upstream focus on renewables and decentralized energy with conventional generation only as a back-up, (ii) midstream focus towards the creation of local distribution networks feeding into a smart and Pan-European transmission grid and (iii) downstream focus on services and facilities maintenance instead of supply. The pace of change will vary by country and plenty of stumbling blocks exist, the biggest of which is the lack of innovation track record in the utilities sector. However, the trajectory of change in our view is set and although the pace will be evolutionary (two plus decades), the outcome will be revolutionary (Citi 2013).
Barclays	In the 100+ year history of the electric utility industry, there has never before been a truly cost-competitive substitute available for grid power. We believe that solar + storage could reconfigure the organization and regulation of the electric power business cover the coming decades (Barclays 2014).
UBS	Solar systems and batteries will be disruptive technologies for the electricity system. Steeply declining battery and solar system costs will enable multiple new applications… Our proprietary model suggest a payback time as low as 6-8 years for a combined EV + solar + battery investment by 2020 – unsubsidized (UBS 2014).
Moody's	Large increases in renewable energy have had a profound negative impact on power prices and the competitiveness of thermal generation in Europe. What were once considered stable companies have seen their business models severely disrupted. Given that further increases in renewables are expected, these negative pressures will continue to erode the credit quality of thermal based utilities in the near to medium term (Moody's 2012).
Nomura	There is no let-up in the dire outlook for utilities. In particular, we believe that the outlook for generation remains unattractive, with overcapacity and a squeeze from renewables build, a tepid demand outlook owing to the economy and the promotion of energy efficiency measures (Normura 2012).
CitiBank	This is not a 'tomorrow' story, as we are already seeing utilities altering investment plans, even in the shale-driven U.S., with examples of utilities switching plans for peak-shaving gas plants, and installing solar farms in their stead (Citi 2013).

UBS	Thanks to significant cost reductions and rising retail tariffs, households and commercial users are set to install solar systems to reduce electricity bills – without any subsidies. The economics look set to work best in Germany, Italy and with a time-lag, Spain. We estimate up to 18% of the electricity demand could be replaced by self-producing solar power in these markets (UBS 2013).
Deloitte	The more traditional business models that have served the electricity industry so well in the past simply may not be enough this time – the time for true innovation in the electricity sector may have arrived. By the application of insight and ingenuity, when the year 2020 comes, the successful company may well look very different from the electricity business we now know (Deloitte 2012).
Deutsch Bank Research	The avid interest is being driven by two megatrends that are currently shaking up the traditional order of global power generation and supply and might fundamentally recast it in future. There are currently at least two major battles being waged in the contest between the different power generation inputs. Firstly, at the centre of the fossil-fuel input segment a fierce contest is unfolding between coal and gas, and its outcome is likely to determine the success of future power plant investments by the utilities. Secondly, there is the expanding international scale of the attack by renewable energy sources on established, mostly fossil fuels (DBR 2013).

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