System change in a regulatory state paradigm: the "smart" grid in the UK[1]

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1. Introduction

This paper examines one aspect of the political dynamics of the transition to a more sustainable energy system in the UK. The focus is on 'smart grids', which involve innovation in regulated monopoly electricity networks. The smart grids agenda is central to more sustainable electricity systems, as it will be essential for facilitating more flexible demand, needed for balancing variable renewable generation, as well as incorporating local small-scale technologies such as solar PV, and new technologies such as electric vehicles.

There has been increasing interest in recent years in smart grids from economics (Pollitt and Bialek 2008), innovation studies (e.g. Bolton and Foxon 2010) and energy policy studies (Woodman and Baker 2008, Shaw et al 2010) as well as think-tanks (Cary 2010). While these analyses all touch on aspects of changes in regulatory and policy frameworks that are political in nature, they are mainly concerned with policy analysis and recommendations, and do not take an overtly political perspective on the intended shift towards a smart electricity grid. By contrast, here my focus is explicitly on the interplay between the ideas, institutions and interests that surround the immediate debates on policy for smart grids. The underlying goals are first to understand how the governance of networks is affecting attempts to bring about low carbon innovation in networks, and second to determine what determines governance and governance change.[2] In the conclusions I do draw out some implications for policy, especially the design of institutions, but these are preliminary in nature.

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The studies mentioned above also all pre-dated important recent developments in electricity network regulation, notably a major review of the regulatory regime in 2009-10 (RPI-X@20) and the launch of a new regime subsequently (RIIO). The energy regulator in the UK linked both these developments to the need to move to a low-carbon energy system, with the implication that the old RPI-X regulatory framework was insufficient and that a major change would be needed. The background to regulatory change was a wave of concern about climate change in the UK in the 2000s, the passage of the Climate Change Act and considerable criticism that Ofgem was a barrier to decarbonisation. However, in this paper I argue that despite the considerable political pressure that Ofgem came under, RIIO represents 'evolution rather than revolution' in the regulation of electricity distribution networks, especially in terms of innovation. The key analytical question is then why major political pressure has led to only gradual rather than major change. Here I argue that the answers lie both in the nature of external pressure on Ofgem and in the institutional legacies of the original design of electricity regulation in the late 1980s.

The paper is structured as follows. In the next section, I clarify the questions addressed in the paper, and identify theoretical frameworks for first assessing and then explaining governance change. In section 3, the 'smart grids' concept is briefly explained, along with why it is important for a more sustainable electricity system. This section also briefly reviews arguments about the need for governance change for smart grids. Section 4 gives a summary account of what has happened in electricity network governance since privatisation, with particular focus on more recent events. In section 5, the significance of these changes is assessed, not only in terms of their likely impact, but also in relation to the pre-existing regulatory paradigm. Section 6 presents an attempt at explaining what changes have occurred, and why others have not. Finally, section 7 concludes with some observations on governance arrangements, drivers of change and Britain in comparative perspective.

2. Theoretical framework

Studies of the governance arrangements and innovation in electricity networks have tended to use economics or innovation studies as frameworks to assess existing governance arrangements and make recommendations for specific policy changes intended to increase innovation. Here, the purpose and focus is somewhat different, being more on understanding and explaining what change has happened, and not happened, in electricity distribution network governance and innovation outcomes. Such change is conceived of here as primarily a political process, and I draw on frameworks from within political science, especially new institutionalist theory and analyses of regulatory change. In the conclusions I do draw out the implications of the analysis for policy, especially the design of institutions, but these are preliminary in nature.

In this paper, I seek to address three questions. The first of these is *what change has actually occurred in the governance arrangements of electricity distribution networks in the UK*. Discussed in section 4, this is primarily an empirical issue, addressed through an examination of the record of events since privatisation and especially since in the period from the early 2000s as innovation for sustainability became increasingly important in the policy debate.

The second question is *what the significance and nature of this change is*, i.e. how far does it represent a step change both in terms of institutions and the paradigm of network regulation, and in terms of innovation in network investments and operation? Here, a useful classification is provided by Black (2005), who applies Hall's (1993) distinction between three variables or levels of policy to regulatory change. First-order changes, i.e. changes in the settings of regulatory instruments (for example the 'X' factor in RPI-X) are not innovation, but rather normal regulatory practice. Black notes that this does not mean that such changes cannot be significant (for example between DPCR4 and DPCR5 'X' moved from being negative to being positive, signalling a large increase in distribution charges). Moreover, "the cumulative effect of several first-order changes may over time have radical or transformative effects." (ibid: 9). However, they do not signal innovation as such.

Black defines second-order changes in regulation as changes in the "techniques or processes" being used, citing a shift from price-cap to rate-of-return regulation as a possible example (ibid: 10). They may also include the construction of new regulatory institutions, such as new agencies. Crucially, Black notes that "[b]ecause second-order changes occur within existing normative and cognitive paradigm, they may serve to entrench those paradigms, and thus, paradoxically, may be stabilizing in their effects, and may not in practice have the 'reformatory' effects that may have been intended…" (ibid: 10).

By contrast, third-order changes represent changes in the paradigm governing the regulatory regime (Hall defines a paradigm as an interpretive framework of ideas and standards that is "embedded in the very terminology through which policy makers communicate about their work…influential precisely because so much of it is taken for granted and unamenable to scrutiny as a whole" (1993: 279). Such changes will involve "significant transformations in instruments, institutions and organizational structures and processes arising from radically changed cognitive and normative structures" (ibid: 10) – Black gives renationalisation as an example. Such third-order changes are, considers Black, regulatory innovation, or may lead to such innovation: "In regulatory terms, [innovations] are significant transformations in instruments, institutions and organizational structures and processes arising from radically changed cognitive and normative structures, and may be accompanied by first-order and second-order changes." (ibid: 10)

Black's classification thus provides a framework for assessing the nature and significance of change. Similar recent analyses of wider energy policy using Hall's original framework have been undertaken by Kern and Mitchell (2010), Kuzemko (2013) and Kern et al (forthcoming), all of which argue that there has been significant change on all three levels since the 1990s, but that key elements of a market-led paradigm still remain.

The third question addressed in this paper is *how can we explain what change has occurred, and why more change has not yet happened?* As Peters (2012: 112) notes: "The basic logic of institutions in most conceptualizations is that they provide permanence and predictability for society, even in the midst of turbulent political activity" and hence such conceptualisations are better at explaining persistence than change, especially rational choice and historical institutionalism (e.g. Hall and Taylor 1996: 952, Peters 2012: 77-83, 182). In such theoretical frameworks, major transformative shifts are typically explained by exogenously driven shocks or pressures that create crisis (Mahoney and Thelen 2010: 4-7; Kingston and Caballero 2009; Peters 2012: 62-63), sometimes characterised in historical institutionalism as 'critical junctures' (Cappocia and Kelemen 2007) which lead from one steady state to another. Gradual change is more likely to be seen as generated by processes of evolution which may be driven by the deployment of ideas by actors, but in which existing institutional templates and underlying discourses limit the range of possibilities, creating path-dependence (Campbell 2004; Mahoney and Thelen 2010).

A key problem for analysing major change in response to external pressures or shocks lies in knowing why such forces do sometimes lead to major change and why they do not (e.g.

Peters 2012: 78). Cappocia and Kelemen (2007: 338) define critical junctures as "*relatively* short periods of time during which there is a *substantially* heightened probability that agents' choices will affect the outcome of interest" (emphasis in the original), but argue that "contingency may imply that wide-ranging change is possible and even likely, but also that re-equilibriation is not excluded", so that "change is not a necessary element of a critical juncture" (*ibid*: 352). The question of why 'critical junctures' do sometimes not lead to transformative change is particularly relevant to understanding change in the regulatory framework for electricity distribution networks. As discussed in detail below, despite a major transformation in the politics of climate change in the second half of the 2000s, the resulting change in regulation has been relatively minor.

Here, I argue that the degree to which greater contingency was opened up depends *both* on the exact nature of the external pressure on the institutions governing electricity distribution networks, *and* on the nature of institutional response, especially from Ofgem and the network companies. In the latter case, the role of ideas, policy entrepreneurship and *bricolage*[3] are likely to be particularly important. In the literatures on policy learning (e.g. Peters, Pierre and King 2005), discursive institutionalism (e.g. Campbell 1998, 2004) and gradual institutional change (e.g. Mahoney and Thelen 2010), emphasis is given to the strategic deployment of ideas by actors in order to make change. However, it is equally possible that such deployment can also be made to defend existing institutional objectives and policy paradigms under episodes of heightened contingency precisely so as to try to *avoid* major change.

3. The 'smart grid' concept

The concept of a 'smart grid' has emerged in recent years as a core element of a more sustainable electricity system. There is no single agreed definition of a smart grid, but the basic principle is the application of information and communication technologies (ICTs) to electricity networks to allow: greater observation of the state of wires and other assets; control of power flows; automation of management of power fluctuations of outages, and integration of new low carbon generation and demand side technologies, such as solar PV, heat pumps and electric vehicles (DECC 2009: 14).

[3] *Bricolage* refers to the process of creating change by tinkering with existing collection of ideas rather than creating an entirely new approach (e.g. Carstensen 2011)

The smart grid agenda applies largely to the low voltage distribution networks, as the high voltage transmission system is already 'smart' to some degree. Existing electricity distribution infrastructure has been developed to serve predictable and regular patterns of demand and generation (Shaw et al 2010: 5927). Almost all electricity generation has been centralised in large power stations, with a one-way passive network sending power from those power plants to consumers. If electricity generation and use is to become more sustainable, networks will have to be transformed in the way that they work.

First, a low carbon electricity system will need a much higher proportion of renewable generation. A significant proportion of renewable capacity, including onshore wind and solar PV, is likely to connect directly to distribution networks. These have been designed purely to push power to households, businesses and industry rather than to *absorb* power from sources such as wind turbines and solar photo-voltaic (PV) panels (Ochoa et al 2010).

A second issue is the balancing of the system. Electricity systems have to maintain a constant balance between demand and supply in real time to avoid blackouts. Currently this is achieved by matching supply to regular patterns of demand for electricity (peaking in the morning and early evening), with power stations being deployed or withdrawn over the course of the day (and indeed over the year). However, renewable electricity technologies produce varying output of power with changing patterns of wind and sun etc. Low carbon electricity systems will therefore have to vary demand to match supply, along with a greater role for electricity storage. Smart meters will play a crucial role in this process.

A third issue is the anticipated electrification of both heating and transport. In a low carbon future, the Government anticipates that a significant proportion of heating will come from low carbon electricity using heat pump technologies (DECC 2013). At the same time, internal combustion engines are likely to be replaced by batteries in electric vehicles. Both these developments will add considerably to the demand on the electricity system, increasing the value of more efficiency in network design and use (The Climate Group 2008). However, they also potentially provide very useful new ways of balancing the electricity system, because they effectively introduce distributed forms of mass energy storage on the demand side (e.g. Strbac et al 2010).[4] This means that grids must be able to communicate with heat pumps, electric vehicles and appliances, through smart meters.

Network operators will want to be able to observe how much power is flowing where, in real-time. They will want to be able to manage and optimise demand as far as possible, effectively evolving from network operators to local electricity *system* operators. It will also be helpful to automate much of this process (Northcote-Green and Wilson 2006).

This vision contrasts sharply with the grid that the UK has at present. Parts of the distribution network date back to the early part of the last century, and levels of system observability are very poor. Building a smart grid is therefore a major undertaking, with considerable costs. In the UK the roll-out of smart meters alone is projected to cost £12 billion, with other system elements potentially costing in the region of £10 billion (ENSG 2009: 20-22). However, as Cary (2010) notes, there is also an opportunity, since the existing distribution network is ageing fast, and need to be replaced in any case. Many assets (wires, transformers, switching equipment etc.) are over 40 years old, dating back to a major wave of investment during the nationalised period in the 1960s (e.g. Pollitt and Bialek 2008 Figure 1; Bolton and Foxon 2010: 15) and even by the late 2000s an estimated 70% were reaching the end of their design lives (Mitchell 2008: 150). Investment needs have already risen sharply.

4. Innovation and the governance of electricity distribution networks to the late 2000s

It is widely argued that the transformation of distribution networks will also require major changes in the *governance* of the bodies that invest in and operate those networks. Since 1998, networks have been run by private companies known as distribution network operators (DNOs) (Helm 2003: 258). There are 14 DNOs in Great Britain, which distribute electricity to all consumers in their geographical area. While generation and supply (retail) of electricity have been liberalised, networks remain regulated as natural monopolies. Since 2000 the electricity regulator has been located in the Office of Gas and Electricity Markets Authority (Ofgem).

[4] For example, in principle, millions of electric vehicles with batteries could be charged up overnight when wind generation is peaking but other sources of demand are low, and then those same batteries could be discharged back into the grid to help meet morning peak demand if wind speeds drop away.

The approach to regulation of electricity networks up until very recently was originally set at privatisation in the late 1980s, and is known as 'RPI-X'.[5] Electricity supply companies pay a charge to the DNOs for the use of the network, which is passed on to consumers. The amount that can be charged, and hence the revenue of the DNO, is set by the regulator for a certain period (up until 2015 these have been 5 year periods known as 'distribution price control reviews' or DPCRs). Ofgem also agrees an investment programme with the DNOs. Each company's overall revenue allowance is then adjusted firstly to take account of inflation (i.e. the RPI) and secondly by a factor 'X', which is intended to induce efficiency gains.[6] A number of additional incentive schemes related to the performance of the DNO, for example in avoiding blackouts and providing connections within a certain time period, are also then applied. Any savings that the company can make within this revenue envelope can be retained by the company as profit, and distributed to shareholders.

Most observers argue that the RPI-X regime increased efficiency, especially on the operating side, but has not incentivised long-term technological innovation or innovation in business models. One senior Ofgem figure argued in 2010 that "It would be crude but not an unrealistic simplification to say that the way energy networks are designed, built and operated has not changed significantly since they were built in the post war period." (Smith 2010: 9).

At a high level, successive governments have made several changes to the remit of Ofgem through legislation or guidance over the 2000s, apparently intended to increase the attention given to climate change and decarbonisation of the energy system, amongst other things (see Figure 1). When Ofgem was created in the 2000 Utilities Act, its 'principal objective' was defined in legislation as protecting the interests of not only existing but also *future* consumers, with the intent that this created an obligation for Ofgem to consider long term sustainability in its regulation of the energy industry. In 2004, this imperative was strengthened through the Energy Act which introduced the need for Ofgem to consider its contribution to sustainable development as a secondary statutory duty. In the 2008 Energy Act, the requirement to consider sustainable development was raised from a secondary duty to part of the primary duty. In the 2009 Energy Act, the language of the principal objective was altered, to clarify that the interests of consumers include the reduction of GHG

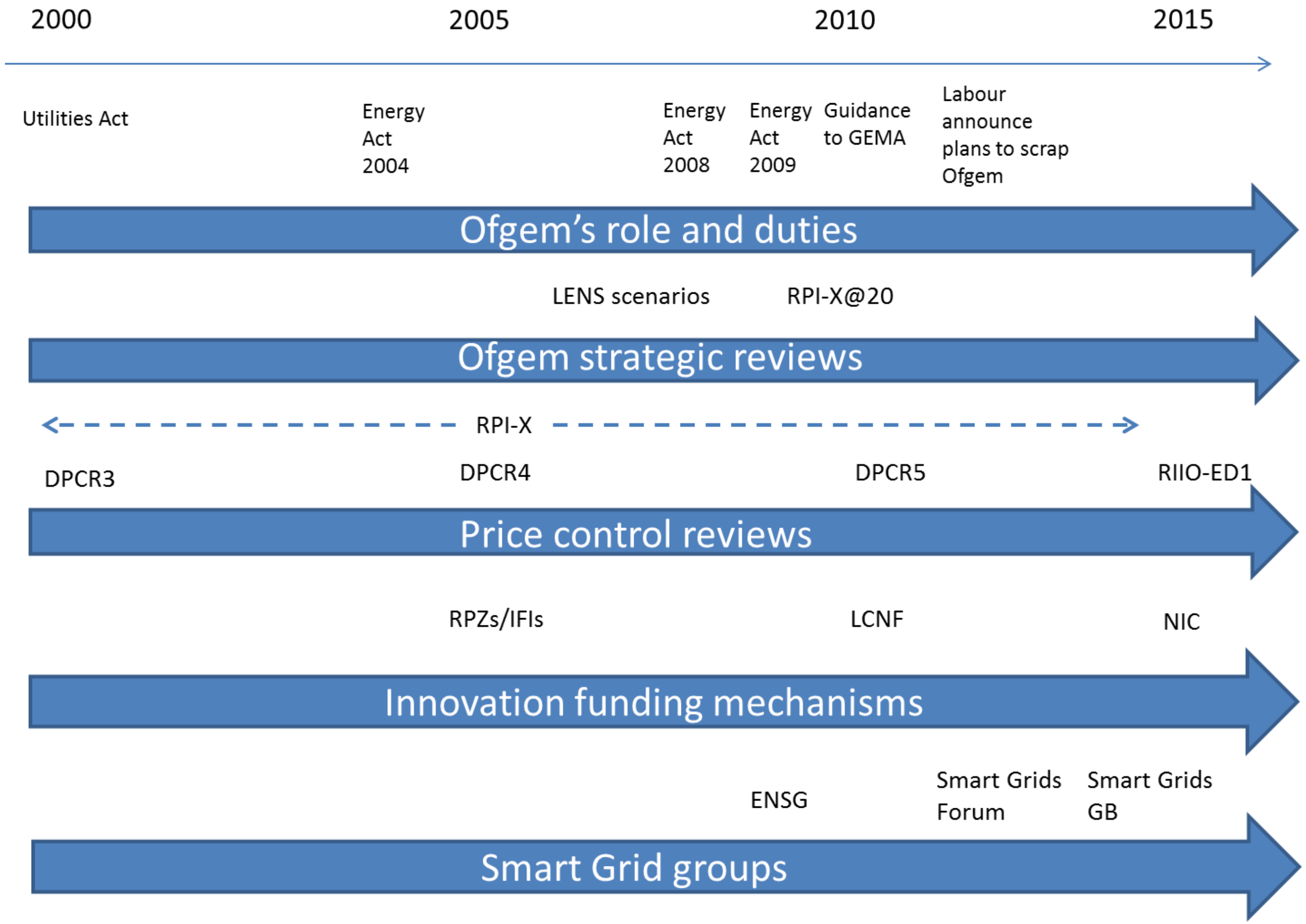
[5] For more detail on the RPI-X process in distribution price control reviews, see Jasamb and Pollitt (2007).
[6] For details of the process of setting the cap see Jamasb and Pollitt (2007: 6170-71).

emissions. In January 2010, the government issued revised guidance to Ofgem's governing Authority, sharpening the requirement for Ofgem to regulate networks in such a way that they identified and planned for a low carbon future. Despite all these changes, the new coalition Government instituted a review of Ofgem in early 2011, and currently proposes to give greater direction to Ofgem through 'Strategy and Policy Statements' which are being introduced under an Energy Bill currently going through Parliament.

The innovation agenda for network regulation has evolved over the 2000s, partly in response to these high-level changes. However, it was clear that by the late 2000s, there were a number of issues that remained unresolved. These can be grouped into five areas:

- The connection of *distributed generation* (DG), including from renewable technologies, to distribution networks (Woodman and Baker 2007; Pollitt and Bialek 2008; Shaw et al 2010). Despite reductions in connection charges for individual distributed generators, the wider sharing of DG benefits with customers, changes to engineering standards and a specific DG connection incentive for DNOs, all introduced over two price control reviews from 2005 onward, distributed generation grew far less than expected over this period. The DG incentive was seen as ineffective (Woodman and Baker 2008: 4529-30), partly because it was more than offset by other incentives, including the loss of revenue from distributing centrally generate electricity (Shaw et al (2007: 4). By 2012, Ofgem was admitting that it had had little effect (Ofgem 2012). More fundamentally, DNOs did not see connecting and managing DG as part of their core business, and tended to want to deal with projects on a piecemeal basis (Mitchell 2008: 153; Bolton and Foxon 2010: 16, Cary 2010: 68). Proposals for how to remedy this situation mainly focused on increasing the incentive to reduce losses, as more DG would help with loss reduction (Shaw et al 2007, Cary 2010, Pollitt and Bialek 2008), and on the need to take a more strategic and coordinated approach to DG connection (e.g. Cary 2010: 68).

Figure 1
Electricity distribution networks/smart grids governance timeline



- *Research and development* (R&D) on networks. By 2004, UK network companies were spending less than 0.1% of revenue on RD&D (Pollitt and Bialek 2008:   ). In DPCR4 (2005-2010), Ofgem introduced two sources of funding for experiments in technological and commercial innovation. One was the Innovation Funding Incentive (IFI), allowing DNOs to claw back costs of R&D up to 0.5% of revenue. The IFI increased R&D spending by DNOs from around £2 million in 2003/04 to around £12 million in 2008 (Jamasb and Pollitt 2011: 313). The second was Registered Power Zones - a scheme aimed at demonstrating innovative solutions to the connection of new distributed generation (Mitchell 2008: 153). However, only a handful of schemes materialised in the price control period (Woodman and Baker 2008: 4529; Bolton and Foxon 2010: 17; Mitchell 2008: 154). By the late 2000s there were calls to increase the scale of funding (Pollitt and Bialek 2008) and to allow more collaboration across the value chain, with consumers, suppliers and ICT companies (Cary 2010). In DPCR5 (2010-2015), a new Low Carbon Network Fund (LCNF) was set up, which allowed DNOs to bid for up to £500 million over 5 years (Ofgem 2010), an order of magnitude larger than the IFI, as well as being significantly bigger than comparative schemes in other countries. This scheme allowed DNOs to cooperate with suppliers, generators and consumers in projects, and also required findings from projects to be shared publicly.[7]

- The *bias towards capital spend* amongst DNOs. As Smith (2010:) notes, there is a tendency amongst DNOs to "solve problems with investment in physical assets", sometimes characterised as a 'fit and forget' approach (e.g. Shaw et al 2010: 5930). This works against smart grid principles of solving problems through more intelligent operation and management of networks, including more DG.[8] Although RPI-X was originally chosen partly to avoid the incentive for companies to seek to maximise capital investment under rate-of-return investment,[9] it does in fact contain an implicit rate-of-return on capital, so this effect is not eliminated (Newbery 2003). In addition, while there was a specific mechanism to bear down on operating costs, there was no such equivalent for the bids made by companies to Ofgem for investment expenditure (Jamasb and Pollit 2007). In DPCR4 (2005-10), Ofgem introduced a new mechanism aimed at incentivising

[7] Findings from LCNF projects are available on: http://www.smarternetworks.org/index.aspx
[8] Mitchell (2008: 151) citing estimates from a 2001 study of savings on network reinforcement costs of up to £100/kW in urban areas from active network management and DG
[9] Known as the 'Averch-Johnson' effect.

companies to put in lower bids for capital spend, allowing them to keep a larger proportion of any underspend compared with companies that put in higher initial bids. However, critics still argued that separate treatment of operating and capital expenditure prevented rational treatment of the trade-offs that would be needed for smart grid operation, and called for integration across total expenditure (known as 'totex') (Pollitt and Bialek 2007, see also Cary 2010: 69). More fundamentally, even if incentives for efficiency were balanced, it was argued that the risk aversion of DNOs, and uncertainty about untested operational approaches such as demand side response and DG means that a bias to capital spend is likely to remain (Shaw et al 2010: 5934). As Smith (2010:) put it, there is a "natural desire amongst engineers to put more faith in physical assets than commercial arrangements and new contracting and pricing arrangements to manage capacity constraints or uncertainty".

- *Uncertainty about future network needs* and operation. While there are plenty of visions of a future electricity system in the UK, there is still a great deal of uncertainty about what it will look like, what the path to it will be, and how to regulate for such uncertainty (Pollit and Bialek 2008: 12). The regulatory framework of the 2000s was based on a requirement to demonstrate need before investment was deemed efficient, making 'anticipatory investment' for the potential future use of low-carbon technologies risky for companies (Shaw 2012: 5932; Cary 2010: 79). One approach to the problem of uncertainty is to allow evolution by experiment and deeper engagement with network users to understand potential future uses (e.g. Pollitt and Bialek 2008). The other is to move in the opposite direction towards a greater degree of strategic coordination (Smart Grid GB/Ernst and Young 2010, ENA 2009b, Skillings 2010, IET 2009, Sansom 2010), to ensure common standards and interoperability (Shaw et al 2012: 5932), to overcome the problem that some of the benefits of the smart grid will fall to actors who are different from those who have to make investments (Bolton and Foxon 2010: 20),[10] and to bring together a number of potentially disparate elements in compatible ways to realise the full benefits of smart grids.[11] For example, by the late 2000s it was clear that a lack of

[10] The particularly thorough privatisation and unbundling of the electricity industry in the UK means that the need for such coordination is greater than in other countries (e.g. Bolton and Foxon 2010: 20; Carey 2010: 67). Ironically, although this situation implies a much greater role for government, the privatisation process itself has hollowed out the technical expertise that would be needed (e.g. IET 2009)

[11] These elements, termed 'solution sets' by the Smart Grid Forum (2011) include distributed generation (including intermittent renewables), smart meters and automated home systems, controllable electric vehicles

coordination between the smart grids agenda and the design and roll out of smart meters, which was being led by suppliers, risked missing crucial potential benefits for reducing network investment requirements through peak demand reduction. Both those against and for coordination argue that their approach would avoid overinvestment and stranded assets. As Smart Grid GB (2010:) note, greater coordination would require anticipatory investment, and a major change to Ofgem's approach of "wait for proven need and provide optimal solution".[12] Shaw et al (2010) call for scenario based planning.

- Issues of *ownership and competition*. As monopolies, DNOs are expressly banned from owning any generation or having any supply relationships with customers, to prevent them from favouring their own business over other network users. However, this rule poses a barrier to DNOs becoming active distribution system operators (DSOs), who would actively manage and balance power flows on the network, as access to distributed generation, storage and demand side response would be needed to do this effectively (Shaw et al 2010: 5934-35; Cary 2010: 79, Bolton and Foxon 2010). At the same time, Pollitt and Bialek (2007: 18) argue that the large integrated supplier-generator energy companies that own a majority of the network businesses should be forced to divest them, on the grounds that if DNOs become more active network managers, they could effectively give priority to parent company demand side or DG contracts. More radically, Pollitt (2010) explored the options of introducing more direct competition, either by allowing third parties to build, own and operate new parts of networks, or even the construction of parallel networks that would give customers a choice, for example between the main grid and micro-grids.

Partly in response to these debates on innovation, Ofgem started to undertake a number of strategic reviews of the electricity system and its regulatory frameworks in the latter part the decade. In 2006, Ofgem set up a project looking at long-term future scenarios for electricity networks (Ofgem 2008). This 'LENS' Project included radical options for distribution networks, relevant for smart grids, including the concepts of 'distribution system operators'

charging and heat pumps, data handling systems, network sensing, active network management and automated intelligent network devices.

[12] This is despite the fact that in 2010 DECC issued guidance to Ofgem's governing Authority that, according to the network industry association, the regulator "should carry out its functions in a manner that will secure that an early start by network companies in identifying and planning necessary 'strategic' investments in electricity networks should take place before firm commitments from generators are required." ENA (2010: 2-3), i.e. moving away from a 'wait for need' approach.

in which network operators control and balance power flows, and micro-grids, where consumers also become generators, and manage networks themselves. However, this remained a scenario exercise, with no direct connection to actual regulation.

More significantly, in late 2008 Ofgem started what it called a ‘root and branch review’ of the overall regulatory framework for networks, called ‘RPI-X@20’ because RPI-X regulation had been in place for around 20 years (Ofgem 2009). RPI-X@20 was motivated partly by the low-carbon energy agenda, but also by a set of issues to do with greater consumer engagement and the idea of regulating for outputs rather than simply cost. It was premised on the idea that RPI-X had been largely successful in reducing costs and raising efficiency. RPI-X@20 ran over a two-year period, and like the LENS scenario exercise opened up the debate on network regulation to some quite radical ideas, including direct competition in distribution at local level and a more strategic approach to investment. However, the final decision document which was to feed into the next round of regulation for the period following 2015, maintained many aspects of the basic structure of RPI-X.

Nevertheless, RPI-X@20 did engage fully with the smart grids concept, which by this time had started to attract attention. In 2009, the Electricity Networks Strategy Group of the energy distribution industry body ENA, produced a high-level plan and an attempt at a cost-benefit analysis for smart grids in the UK (ENSG 2010a) along with a ‘route map’ (ENSG 2010b). Shortly after these reports were produced, DECC and Ofgem established a Smart Grids Forum, with representatives from the DNOs and some independents. The Forum has produced a number of reports on various issues, including a more complete framework for evaluating the costs and benefit of smart grids, scenarios for the uptake of low carbon technologies at regional level (EA Technology 2012), a detailed description of expected functionalities of a smart grid by 2020 and 2030 Smart Grid Forum (2011), and an assessment of regulatory and commercial barriers to the smart grid (Smart Grid Forum 2012). The work of the SGF has fed into RIIO, and has also led to other developments, such as reform of the main engineering rule that had been identified as a potential barrier to demand side response (Kay 2012). At the same time, the ICT industry, which has a clear interest in the smart grids agenda, has set up an organisation called Smart Grid GB, which has also produced a social cost-benefit analysis (Smart Grid GB/Ernst and Young 2012). Meanwhile the government produced its own vision statement for smart grids (DECC 2010). The Energy and Climate Change Select Committee also held an inquiry into future electricity networks (ECC Select Committee 2010).

The RPI-X@20 review led to what Ofgem have presented as a new regulatory model for networks, called 'RIIO', standing for 'Regulation = Incentives + Innovation + Outputs' (Ofgem 2013). RIIO applies across both gas and electricity, and to transmission and distribution. The new price control review under the RIIO approach will be known as RIIO-ED1 and will run from 2015 to 2023.

Given the history of distribution network regulation up to the late 2000s, and the proposals for change noted above, a key question is how far the shift from RPI-X to RIIO goes in introducing these changes. It is to an assessment of how far this shift represents true regulatory innovation that I now turn.

5. The nature and significance of governance change under RIIO

Much of the literature on innovation in electricity distribution networks in the late 2000s pointed to the need for more radical thinking in policy and regulatory frameworks. Writing in 2008, Mitchell argued that "although this issue has been looked at in detail since 2000, there has been very little *actual* change in the design and operation of the networks" (2008: 149) because the nature of regulatory incentives had not changed. Mitchell (2008: 153) also makes the point that any measures introduced to incentivise innovation (such as the IFI and RPZs) still had to be justified in terms of net benefits to customers, showing how Ofgem's core focus on efficiency remained dominant throughout the decade. In Mitchell's terms, the regulator remained on the wrong side of the "innovation fault-line": over-committed to market-mimicking mechanisms; not willing to channel and direct innovation; over-committed to the least-cost option over the environmental option, and seeing innovation as a technology-only issue rather than a 'system' issue (Mitchell 2008: 12-13).

By comparison with DPCRs 4 and 5, one might expect RIIO to represent more of a step change, as it developed out of a strategic review (RPI-X@20), which in turn was a response by Ofgem to quite intense political pressure over the mid-to-late 2000s to engage with the low-carbon agenda. Ofgem itself presented RIIO as a *new regulatory model*, linked to a requirement for "unprecedented" levels of innovation by network companies (e.g. Nixon

2010) and promoting a "step change" in the way that they think about the low carbon future (Ofgem 2103: 5). However, many other observers have taken a different view, for example both the rating company Moody[13] and Consumer Focus (2009: 5) arguing that RIIO represents more "evolution than revolution" relative to DPCR5. The wind industry body, RenewableUK, took the view that the RIIO proposals represented "business as usual rather than the paradigm change required." (RenewableUK 2010: 5). One independent but informed industry observer describes it as "RPI-X with bells and whistles".[14]

In this section, I attempt to assess the nature and extent of change under RIIO ED1 from the point of view of the smart grids agenda, whether it constitutes regulatory innovation, and if so, of what nature. My approach is to examine how the RIIO framework treats the five areas identified as important for the smart grid agenda in the previous section, and assess, using Black's (2005) framework discussed in section 2 above, what order of change, if any, is involved.

For the connection of *distributed generation*, the RIIO framework drops the DG incentive, which it argues was ineffective and too complex. Instead, Ofgem has decided that DG should be treated within the general framework of incentives for good connection and other services that covers demand users: "In RIIO ED1 there will be a range of incentives and mechanisms to encourage DNOs to better facilitate the connection of DG to the network" (Ofgem 2013b: 26). Three mechanisms are mentioned in particular: one to incentivise engagement with major customers, which includes distributed generators, one to penalise failure to meet minimum connection times and quality, and one broader measure of customer satisfaction. (*ibid*: 28-29). The financial penalties involved in the mechanisms are limited (although higher than for DPCR5), up to 0.9% of revenue in the case of the engagement incentive, and a range of payments from £10 to £270 a day under the guaranteed standards incentive (*ibid*: 80-82). In terms of charges for connection, shallow charging remains. Ofgem argues that DNOs are incentivised to keep reinforcement costs as low as possible through the incentive to make low investment bids. In RIIO this applies to 100% of total expenditure, instead of part of capital expenditure, so it is stronger incentive, and also allows DNOs to treat all expenditure the same and find smart solutions (*ibid*: 29). In terms of Black's (2005) classification, all of the

[13] http://www.utilityweek.co.uk/news/news_story.asp?id=198272&title=RIIO+is+%91evolution+not+revolution%92%2C+says+Moody%92s
[14] Personal communication, Ed Reed. Cornwall Energy

above are changes in instruments, i.e. second-order changes, or in settings, i.e. first-order changes.

For *resources for R&D*, RIIO replaces the LCNF with an "innovation stimulus" (Ofgem 2103b: 97). This consists of a Network Innovation Competition (NIC), in which companies bid for funds for large scale projects, similarly to the LCNF, and a use-it-or-lose-it Network Innovation Allowance (NIA) for smaller funds, up to between 0.5 and 1 % of revenues. The NIC is resourced at around £90 million a year for the first two years of ED1, a slightly lower level than the LCNF. The NIA requests in draft company business plans sum to around £250m in total over the over the 8 years of ED1. In addition, RIIO contains an Innovation Roll-out Mechanism to fund the roll-out of proven low carbon innovations, with two application windows in ED1.Finaly, DNOs must set out an innovation strategy in their business plans, which includes evidence of how they will incorporate learning from LCNF and other innovation trials into business-as-usual. The R&D resourcing mechanisms are very similar to those already in DPCR5 (indeed, the success of the LCNF is one reason given for maintaining them). Change is limited to the setting of the instrument (i.e. a first-order change). The Innovation Roll-Out Mechanism is a second-order regulatory change, as it is a new instrument (although its effectiveness will depend on the willingness of companies to apply for its resources).

For addressing the *capital expenditure bias*, RIIO's main change is the move from separate efficiency incentives for operating expenditure and capital expenditure to a single total expenditure (totex) incentive. This instrument is fundamentally about ensuring that DNOs deliver outputs at an "efficient cost" Ofgem 2013b: 90), and although it now includes all expenditure, the design of the instrument is effectively unchanged from DPCR5. A new element under RIIO is the requirement for DNOs to consider innovative solutions to network problems, and to produce a smart grid development plan (Ofgem 2013b: 17). There are no universally accepted indicators of what constitutes a smart grid, but Ofgem's guidance refers companies to work by the Smart Grid Forum on particular, qualitatively defined functionalities to be achieved by 2020 and 2030 (SGF 2011). These are based on the assumption that much change to 2020 will be incremental – see below Section 6. Not all companies have separated out their planned spend on smart grid development and investment for low carbon technologies, but for those who have, this is in the region of 2-4% of forecast total spend.[15] The new application of the efficiency incentive to totex could be seen either as a first- or a second-order regulatory innovation, although it will be seen as significant by those regulatory economists who have been calling for it. The smart grid development plan can be seen as a second-order change.

For the inter-twined issues of *uncertainty, anticipatory investment and coordination,* RIIO provides a number of responses. Ofgem engaged with the debate on uncertainty and coordination in the RPI-X@20 review, posing the question as to whether a 'guiding mind' was needed to provide "clear guidance on what should be done to facilitate delivery of security of supply, environmental and fuel poverty targets." (Ofgem 2009a: 39), and publishing a specific consultation document on decision making about the shape of future energy networks (Ofgem 2009b). This latter paper laid out three options: a 'central government led' model, a 'joint industry led' model, and an 'adapted regulatory framework' model. While a central government led model was acknowledged to potentially speed up change in networks, it was rejected on the grounds that it might be excessively costly and not allow enough innovation. The joint industry led model was also rejected, with Ofgem (2009b: 15) arguing that the adapted regulatory model "is potentially the most likely to ensure value for money for existing and future consumers over time". Unlike the other two models, the adapted regulatory approach was not centralised, but rather left decisions on what network companies would need to do with those companies and Ofgem, taking into account higher level Government and EU targets (Ofgem 2009b: 12). The main reason put forward for preferring this approach, (which has effectively been adopted under RIIO-ED1) is that, because of the considerable uncertainty about what the efficient option for a smart grid is, any centralised approach risks imposing risks that are far more expensive than they need to be, relative to a more evolutionary and incremental approach.

Within this approach, RIIO delegates to DNOs the task of forming 'best views' about the growth of low carbon technologies (e.g. heat pumps, electric vehicles, solar PV, wind etc.) on their networks in their business plans, along with investment plans for accommodating these technologies, and a smart grid development plan, as noted above. The price control review

[15] The companies are: Northern Powergrid, with a proposed smart grid plan spend of £87 million out of total ED1 spend of £4 billion; SP Energy Networks, with a spend of £200 m, including connection of LCTs, out of a total of £5.2 billion,; and SSE, who plan to spend £127 on "innovation" out of a total of £3.9 billion. Business plans are available at: http://www.ofgem.gov.uk/Networks/ElecDist/PriceCntrls/riio-ed1/Pages/index.aspx

period has been lengthened to allow investments with long payback periods, allowing DNOs to take more risk in principle. A mechanism for managing uncertainty has also been introduced; when actual load-related expenditure (including on low carbon technologies) diverges from forecasts by more than 20%, there is a "re-opener" that allows the revenue cap to be adjusted, thus limiting the risk that the DNO takes. DNOs are also allowed to pass through any fixed costs of smart metering data they incur, until 2019. Acknowledgement of the need to plan for the growth of low carbon technologies on the basis of scenarios is the closest that Ofgem has come to approving strategic, or anticipatory, investment, although it falls short of the kind of more strategic coordination that many critics were calling for, and cannot be seen as a more fundamental third-order regulatory change.

Finally, on the issues of *ownership* boundaries, RIIO offers no change to established models. This should be expected, since allowing DNOs to own storage or generation at any scale would involve a change to licence conditions and possibly engineering codes, both of which are outside the scope of a price control review. The Smart Grid Forum has examined some of these issues (SGF 2012), but as with earlier working groups, it cannot itself make regulatory changes. Similarly, RIIO does not touch deeper network governance issues, such as the fact that some elements, such as review of technical codes, comes close to self-governance, with distribution companies playing a dominant role.

Although Ofgem has now laid greater emphasis on innovation for a low-carbon future as a policy goal for distribution network regulation, it is not at all clear that RIIO-ED1 represents true, third-order regulatory innovation of the type that will accelerate a transition to smart grids. The overall form of regulation, i.e. price-cap, remains the same. At the same time, the principles of Ofgem's approach to regulation, in which the main focus is on achieving minimising costs, maximising efficiency, and avoiding the risk of stranded assets, remain largely the same. Innovation is seen as arising out of incentives for efficiency, along with some additional resourcing. The regulatory paradigm remains in force.

Overall, then, RIIO looks less like true third-order regulatory innovation and more like the continuation of a process of more gradual institutional change beginning from the early-to-mid 2000s. This does not mean that there is no change in regulation, or in related activities, including the large amount of analytical work being done by the Smart Grid Forum, and reforms of engineering codes (e.g. Kay 2012). However, changes in institutions and rules appear to have taken the form of what Streeck and Thelen (2005) call ‘layering’, that is, rather than *displacing* existing objectives, institutions and rules, new ones are *added* on top.

6. Explaining the British experience

In Section 5, I argued that recent changes in electricity distribution network governance (i.e. the move from RPI-X to RIIO) do not represent a major departure from the past, especially from the point of view of the transformation to a smart grid. As noted in section 3 above, most institutionalist theories explain major change in terms of exogenous shocks or pressures. Here, however, it appears that a stable institutional relationship involving the regulator and the distribution network operators was indeed subject to an exogenous shock, or a ‘critical juncture’ in the mid-to-late 2000s, but despite this, network regulation has been characterised by minor, gradualist change rather than a more major paradigmatic shift in institutional objectives and rules. The problem, therefore, is to explain why major change did not occur *despite* an exogenous shock. My argument is that the explanation for this outcome lies in two factors: first, in the nature of the ‘shock’ itself; and second, in the institutional relationship between the government and Ofgem.

6.1 A weak policy ‘shock’

As noted in section 5 above, a number of changes to Ofgem’s remit and objectives have been made since 2000. The wider context for these changes was a significant increase in public concern about climate change from 2004, the Stern Review in 2007, the passage of the Climate Change Act in 2008 following a major civil society campaign, the consequent creation of the Climate Change Committee, the creation of a new government department bringing together energy and climate change and a Parliamentary Select Committee inquiry into future electricity networks (ECC Select Committee 2008).A critical report by the now-defunct Sustainable Development Commission in 2007 questioned whether Ofgem had “kept pace with the climate change imperative and whether the government framework within which it operates is fit for the challenge of moving to a completely decarbonised electricity system by 2050”, and recommended changing Ofgem’s primary duty to reflect this imperative (SDC 2007: 6-8). Civil society groups joined in the criticism, arguing that Ofgem needed more staff with technical knowledge of renewables (Cary 2010: 62). Overall there was considerable political pressure Ofgem was under to become more proactive in engaging with the decarbonisation agenda.

A number of analyses give considerable weight to these political developments (e.g. Bolton and Foxon 2010, Shaw et al 2007, Cary 2010). However, in relation to electricity distribution networks and their transformation to smart grids, I would argue that rhetorical and political pressure was not matched by pressure created by policy. Probably the most important aspect of this lack of pressure concerns the growth of low carbon technologies (LCTs) on distribution networks. The most important technologies from a network point of view are heat pumps and electric vehicles, while solar PV is less critical but still of some importance. Also relevant are more conventional distributed generation technologies, such as gas-fired combined heat and power. The faster the expected growth in these technologies, the faster the movement to smart grid approaches to accommodating and actively managing such technologies on networks is required.

The general approach by Ofgem and the DNOs appears to be that the ED1 period (2015-2023) will see only very slow LCT growth, and can be seen as a preparatory period for ED2: "The take up of low carbon technologies is predicted to increase significantly during RIIO-ED2 and RIIO-ED3…The RIIO-ED1 period represents an opportunity to start to deploy smart grid solutions and get prepared for the more radical network changes that may be required in the future" (Ofgem 2013a: 17). However, this view is itself based on the government's own scenarios and policies. Under the RIIO-ED1 framework, all DNOs are expected to form a 'best view' of growth in such technologies in their distribution areas as part of their Business Plans up to 2023. In developing these 'best views' companies have been expected to draw on a number of scenarios for LCT growth produced by the Smart Grids Forum (EA Technology 2012), which are in turn based on scenarios in the government's *Carbon Plan* (DECC 2011b). In these scenarios (EA Technology 2012: 22) for heat pumps, the 'low' case sees virtually no growth until 2018, and around 1 million installed by 2030. 'Central' and 'high' scenarios show much more growth, but only from 2020 onwards. The 'low' scenario for solar PV sees only a doubling in units installed between now and 2030, while the 'high' scenario shows more rapid growth but only during the 2020s onwards, reaching 16 GW by 2030. For electric vehicles, all scenarios in the set see major growth (i.e. above 1 million vehicles) only with fast-charging technology, and only from the mid-2020s onwards.

Such scenarios depend on a number of factors, including the willingness of people and businesses to adopt new technologies, but they are also very heavily policy dependent. *Thus the assumption of slow uptake of LCTs before the 2020s in these scenarios effectively rests on assumptions about policy, made ultimately by the government itself.* As Shaw et al (2010: 5932) put it:

> "In a privatised energy system with incentive regulation and minimal scope for anticipatory investment, networks will adapt their assets to new demand and generation patterns once they have reasonable certainty of what those patterns will be. Those signals are only conveyed via requests from market participants. Thus the signals to networks are passed from government (sometimes via the regulator) to energy users and to generators and then to the networks."

In fact, where policy has already changed since the underlying assumptions were made, the scenarios already look outdated. In the case of solar PV, the scenarios were constructed in 2011, but have been overtaken by the feed-in tariff. The 'low' scenario sees the number of PV units installed rising to just under 500,000 by 2030, but by August 2013 in fact over 450,000 units had already been installed.[16] On the other hand, the uptake of heat pumps and electric vehicles has been slower than was expected a few years ago. Policy support for both technologies has been relatively weak.

Within this framework, the DNOs have tended to take a conservative approach, almost all adopting the 'low' or 'medium' scenarios (see Annex 1 for details). It is clear that companies prefer to risk undershooting LCT uptake rather than overshooting, and it also appears that they take the view that policy pressure in the form of more rapid growth of LCTs will not materialise. A senior representative of one DNO recently described the Carbon Plan scenarios as "very ambitious" (WPD 2103b: 3). Certainly, the political conditions have changed significantly since the mid-to-late 2000s the wave of public attention to and concern about climate change has subsided and the party political consensus on climate policy appears to have collapsed (Lockwood 2013, Carter 2010). These changes reinforce the sense that, if the late 2000s represented a 'juncture' for institutional change, that juncture has now closed and did not prove 'critical' enough to necessitate radical change. As discussed further below, this

[16] See data on solar PV registrations, available at: https://www.gov.uk/government/statistical-data-sets/weekly-solar-pv-installation-and-capacity-based-on-registration-date

situation contrasts both with some other countries, and also with other aspects of electricity infrastructure.

6.2 Path dependence in the regulatory regime

If part of the reason why more radical change in the regulatory framework for electricity distribution networks has not happened in the move from RPI-X to RIIO was the weakness of government policy drivers, another part lies with the nature of the institutional relationships between the regulator, government and the industry.

There are many potential explanations of Ofgem's resistance to change, including regulatory capture (Mitchell 2008), a conservative culture dominated by economists (e.g. Cary 2010: 62) and engineers (Smith 2010, Bolton and Foxon 2010: 15) and a siloed organisation in which sustainability has been separated off from the core of regulatory incentives (SDC 2007). Here, I argue that the origins of these and other problems lie with the way that electricity regulation was set up, and how it has consequently evolved since. The legacy of the ideas that set the parameters of regulation at privatisation – a regime that incentivises short term efficiency, a regulatory institutional settlement that gives significant discretion to an arms-length individual regulator, and resulting corporate interests in a stable, low-risk business model – has produced several challenges for the smart grids agenda.

Michael Moran (2003: 100-119) describes the complex and contradictory combination of ideas that ultimately determined the regulatory regime within which network companies operated. Moran's overarching thesis is that the UK underwent an abrupt and dramatic transformation in its style and systems of governance in the 1980s, from a world of 'club' governance that dominated the British political, professional and civil service elites for most of the 20th century, in which discretion, limited public accountability and self-governance were highly valued, to a 'regulatory state paradigm', in which rules, measurement and public accountability were the new principles.

This was the context in which the privatisation of energy industries took place, and that process reflected elements of both the old and new paradigms. On the one hand, the ideas of the regulatory economist and the first electricity regulator, Stephen Littlechild, were highly influential in determining the design of the regime applied to the newly privatised electricity companies (Moran 2003: 104-05). Littlechild adhered to an 'Austrian' view of economics, in which the dynamics of market competition are seen as essential to revealing information about costs, and driving efficiency and innovation (Rutledge 2010a: 16-17; Helm 2003: 59). For natural monopoly networks, the objective became how to regulate in ways that mimicked the workings of markets as far as possible (Rutledge 2010a: 18-20; Helm 2003: 207-09). This led Littlechild to reject the main existing regulatory model from the US of 'rate of return' (RoR) regulation, which he saw as providing no incentive for improving efficiency. Moran (2003: 105) emphasises that Littlechild was also sceptical of US RoR regulation because it required the regulator to exercise discretion in making a detailed assessment of the asset base of the regulated companies and assessing what a 'fair' rate of return is, both of which open the regulator to capture (e.g. Newbery 2003: 3-4, Jamasb and Pollitt 2007).

However, as Moran describes, Littlechild's concern to minimise the scope for discretion in a rules-based system were undermined by ideas prevalent in the culture of 'club' government. Club government was in crisis by the 1970s and being dismantled in the 1980s, but its norms and values were still sufficiently entrenched in government to help form the design of regulatory institutions. In particular, and by contrast with the American system with its principles of public accountability and the influence of legally backed direction of regulators, the newly created British system (first seen in the telecomms regulator Oftel and subsequently copied in energy) involved an individual Director General rather than a regulatory board, and a broad framework of powers in a 'light touch' legal framework (Moran 2003: 105-06).

Thus the design of the regulatory regime and institution governing electricity networks was the outcome of a *combination of rather contradictory sets of ideas about efficiency and discretion*. The resulting design has led to three consequences that have shaped the context for attempts to transform electricity distribution networks.

The first set of consequences are the dominance of short-term monetary cost concerns in regulatory objectives, of economists within the institutional culture of Ofgem and an intellectual framework that is suited to marginalist rather than transformative change. To some extent, these also all applied within the government as well as the regulator. For example, in DECC's vision for future electricity distribution networks, the smart grid agenda is seen as "an incremental process" that builds a smart*er* grid over time (DECC 2009: 1), avoiding the aspects (discussed above) in which the smart grid involves systemic change. All actors have struggled to produce meaningful cost-benefit analyses for a set of changes to network investment and operation with long-term ultimately unknown outcomes. However, the emphasis on short-term efficiency and avoiding the risk of stranded assets has been particularly strong within Ofgem.

The second consequence also arose from the emphasis on short-term efficiency (i.e. within five year price control review periods), and concerns the relationship between Ofgem and the DNOs. The process of agreeing capital expenditure for each price control period brings network companies and the regulator into close proximity for a considerable period of time (up to two years). At the same time, network companies have low political visibility, as they have no direct relationship with domestic consumers, and because network reliability has been good in recent years. In this sense, the regulator and network companies may understand each other better than the either party understands government or the wider political landscape.

The incentive regime led DNOs to bear down especially on operating costs, where they shed considerable amounts of labour in the first ten years. However, because the benchmarking approach, intended to mimic competition, was applied to operational costs but not capital costs, the incentive to be as efficient on the capital expenditure side has not been so great (Crouch 2006: 241). At the same time, companies have had a great deal of certainty on revenue flows over the five year period once agreement is reached on the investment programme and the cap (see e.g. Smith 2012, Jamasb and Pollit 2007: 6170-71).

As a result, DNOs tend to have specific characteristics as companies (Ofgem 2009: 21, Sansom 2010). Networks are a low-risk business, attracting capital (especially debt) at a discount. DNOs are risk-averse, and act when required to by users (for example seeking to connect) or by the regulator. They do not have pro-active corporate strategies, but react to the regulatory contract and focus on allowed revenue. The only innovation that the regulatory regime has encouraged is innovation in short-term cost reduction, mainly through labour shedding. The firms lack the capacity, skills and incentives for major long-term technological and operating innovation.

In most cases, the corporate owners of DNOs are large energy firms which straddle the whole value chain, and who are interested in holding distribution businesses as a hedge against changing terms of trade within the value chain (Rutledge 2010). Networks were initially very profitable, as the first price-cap settlement (1990-1995) was set so as to ensure that the newly created companies did well (e.g. Jamasb and Pollitt 2007: 6167). Distribution charges actually rose over this period. As part of the reaction to high profits made by the electricity industry in the period, which included a windfall tax on suppliers in 1997, the next price control period was less generous, and it was following 1995 that the bulk of efficiency gains were made. Nevertheless, networks remained a profitable business, and profits in electricity (and gas) distribution rose substantially over the 2000s (Rutledge 2010b: 235-237).[17]

The regulatory regime has thus created an industry lobby, close to the regulator and dominant in policy for a such as the Smart Grids Forum and in technical code governance, that seeks stability and certainty, rather than innovation. There is some evidence that the RPI-X@20 review and the shift to RIIO-ED1 have begun to change the culture of DNOs. The smart grid agenda, which was previously the domain of enthusiastic but junior engineering staff, has now reached board level.[18] However, evidence such as responses to consultations suggest that DNOs remain risk averse.

The third, and probably most important consequence is that the ability of the government to press new policy objectives on the regulator is severely limited by the latter's independence and discretion – an effect sometimes described as 'regulatory inertia' (Faure-Grimaud and Martimort 2003). As DECC's 2011 review of Ofgem noted, successive changes to the regulator's remit and duties have "not succeeded in consistently and transparently achieving the desired coherence between the overarching strategy and the regulatory regime. This disconnect can be attributed to two characteristics of the existing legal framework: the broad scope of the duties and the weak legal status of the Guidance." (DECC 2011a: 24). The review goes on to acknowledge that the specification of Ofgem's duties has been "intentionally broad to allow the regulator flexibility". This breadth effectively leaves Ofgem to interpret policy, including trade-offs between policy objectives, in the way it chooses (ENA 2010: 2). It is unlikely that any individual regulator, and the wider institution, would want to give up this power of interpretation and discretion willingly.

[17] Interestingly, two DNOs seen by some observers as more open to innovation (NPG and UK Power Networks) are owned by investment funds (Berkshire Hathaway and Cheung Kong Group respectively) (Interview with Rob McNamara, Smart Grid GB and James Harbridge, IntellectUK, 10 July 2013).
[18] Interview with Rob McNamara, Smart Grid GB and James Harbridge, IntellectUK, 10 July 2013

In such a context, where Ofgem cannot veto new duties outright, but retains broad discretion in interpretation, priorities and trade-offs, institutional actors as policy entrepreneurs or 'bricoleurs' also become important (see above Section 2). In particular, Steve Smith, who instigated the RPI-X@20 review, is seen by some stakeholders as having played an important role.[19] The RPI-X@20 review was launched in 2009, and was presented by Ofgem as its response to the climate policy challenge and a thoroughgoing rethink in which a number of radical options were possible. However, the RPI-X@20 review was managed in such a way that the more radical ideas, including introducing competition in network infrastructure (Pollitt 2010), were eliminated, and the resulting new regulatory model showed remarkable continuity with the old. The political pressure on Ofgem in the late 2000s was such that the institution could not make no changes at all, but by setting up and controlling its own review of regulation, the initiative was re-established and the degree of change limited.

7. Conclusions

Innovation in electricity distribution networks will be an essential element in achieving a low carbon sustainable energy system and economy in the UK. The idea of a smart grid, capable of managing a high proportion of variable renewables and integrating electric vehicles and heating, has been around since the early 2000s. By the end of the decade, against the background of a surge in concern about climate change and major developments such as the Climate Change Act, calls for an acceleration of the smart grid agenda were multiplying. The response from the electricity regulator, Ofgem, had been slow and cautious. A number of critical observers argued that more fundamental change in eth regulatory framework was needed, with a greater focus on innovation. Meanwhile successive governments had made a number of changes to the remit of and guidance to Ofgem emphasising the need for the regulator to engage more fully with the climate policy challenge. In 2009, Ofgem began what it described as a 'root-and-branch' review of its regulatory framework. A series of papers in the late 2000s expressed the hope and expectation that a step change would result.

Following the conclusion of Ofgem's review in 2010, a new regulatory framework, called RIIO, has indeed emerged, and this paper assesses the degree to which RIIO does represent a genuine regulatory innovation, using a framework developed by Julia Black (2005). The

[19] Interview with Phil Jones, Northern PowerGrid, 5 July 2013

overall conclusion is that while there are a number of changes in the settings of regulatory instruments, and in the introduction of new instruments, RIIO does not represent what Black considers to be true regulatory innovation, involving a change in the overall paradigm and approach. Indeed, at least until the early 2020s, the new framework takes an explicitly evolutionary and gradual approach to the development of the smart grid.

I also attempt to explain why major change has not been forthcoming. The second half of the 2000s did see major political pressure on Ofgem to change its approach to regulation, but no major transformation was forthcoming. This pattern represents a challenge to institutionalist theories of change, in which such external pressure or shocks play a central role in major change. Why was transformation not forthcoming in this case. I put forward two arguments. The first is that political pressure has not in fact been matched by policy pressure, especially in the form of rapid growth in the uptake of low carbon technologies which would require a smart grid solution. In detailed planning, both Ofgem and the distribution companies are working with a set of government policy scenarios in such growth only accelerates after 2020. In this sense, the juncture of the late 2000s turned out not to be so critical after all, and the evolutionary approach to the smart grid comes as much from government as from the regulator.

Thus, the smart grid is framed in terms of the *future* needs of policies aimed at reducing carbon emissions and tackling climate change. Here, the British approach, as is often the case in other policy areas, is to try to optimise a solution well in advance of taking any action, rather than through learning-by-doing, which is more common elsewhere. For example, although various stakeholders in the British case argue that the UK is well ahead of other countries in developing the smart grid agenda, this is more likely to be true for countries such as the USA, rather than, say Denmark and Germany, where smart grid solutions are having to be developed in a short time frame in response to urgent need. In Denmark, over 20% of electricity is already generated by wind, and around half of the domestic sector is already provided with meters that can give hourly remote readings. Time of use tariffs are expected to be available by 2015 (Danish Ministry of Climate, Energy and Buildings 2013). In Germany, wind generated around 55 TWh of electricity in 2011, compared with around 15 TWh in the UK. By 2012, Germany had 32 GW of solar PV installed compared with 1.6 GW in the UK. The smart grid is now at the centre of political policy debate of Germany because it is the binding constraint now, rather than a likely issue for the 2020s.

A second explanation for the failure of political pressure to transform Ofgem's regulatory approach lies in path-dependencies arising out of the original creation of the relationship between regulator and government. Institutions designed at privatisation maintained an element of discretion from the previous 'club' governance regime, allowing individual regulators a great deal of freedom of interpretation of rather broadly defined duties, making it difficult for government to introduce new policy objectives (inasmuch as it does want to do this), and creating regulatory inertia. The original objective of promoting short term cost efficiency has been inimical to innovation, but has also created a strong economistic culture in Ofgem, and a corporate lobby interested in low levels of risk and predictable returns.

The main implications for policy of this analysis are two-fold. One is that an acceleration of the smart grid agenda in the UK will not occur without a stronger signal from the government in terms of more effective policies to support growth in low carbon technologies. A second is that the institutional relationship between the government and the regulator will need to change. The government is currently proposing to try to reduce the regulator's discretion through the introduction of Strategy and Policy Statements. The opposition Labour party proposes to scrap Ofgem and rethink regulation. An entirely different model (such as the Danish example, where key decisions are really taken by the state run system operator rather than the regulator) might be needed. Which of these may be more effective is beyond the scope of this paper, but the underlying point is that the government will have to find some way of overcoming regulatory inertia if it wishes to accelerate the construction of a smart grid in the UK.

Annex – DNO 'best views' on LCT growth in RIIO-ED1 Business Plans

Company	Business Plan Document	Best view
Electricity North West Limited	Annex 8: DECC Scenarios	"LCT take up will be lower in the North West than the national average. As such we have concluded that the DECC Low scenario is the most probable estimate for RIIO-ED1 for our region." (p. 4)
Northern Power Grid	Annex 1.9 Smart Grid Development plan	"while…we are unlikely to reach the volumes of PV in DECC's high forecast, for PV the assumption of 'medium' is an entirely appropriate one…" (p. 10). In contrast they think HPs and EVs will grow more slowly, with HPs taking off before EVs
Western Power Distribution	Supplementary Annex SA-06 - Uncertainty	Best view estimates are well below DECCs scenarios other than 4 (i.e. buying international credits). WPD thinks the DECC scenarios will not materialise in their regions (p. 8). On the other hand, WPD think there will be a higher degree of clustering of LCTs than in the Transform model, which raises costs (see p 9).
	Minutes of meeting of the WPD Customer Panel meeting on 13 March 2013	Nigel Turvey, Design and Development Manager of WPD is recorded as telling the meeting that WPD view the DECC scenarios as "very ambitious".
SP Energy Networks	Main Business Plan	'Best view' of LCT roll out falls between DECC's low and medium scenarios (p. 194)
SSE Power Distribution	Technical Appendix 04: Getting connected to our network	"Our decision is based on a low LCT take-up (most closely aligned to DECC scenario 4)" (p. 34)
UK Power Networks	Annex 3: Core Planning Scenario	"The graph generally demonstrates that our current baseline uptake rates are towards the lower end of the DECC/Smartgrid Forum forecasts over the long term." (p. 12)

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