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Using investment appraisal models in strategic negotiation: The cultural political economy of electricity generation

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ABSTRACT

Although accepting that the Discounted Cash Flow model of investment appraisal has well known technical limitations, researchers have begun to explore its performative properties. This paper demonstrates how the Discounted Cash Flow model frames negotiations between actors around narratives of economization, marketization and financialization in a regulated industry. Reconnecting economics and politics, the theory of Cultural Political Economy is used to interpret and evaluate an empirical study of Great Britain's electricity generating industry. Although alternative imaginaries, based on political and employment goals, have historically influenced investment decision making in the industry, the current narrative of investment appraisal is dominated by Discounted Cash Flow models. These models have allowed industry players to construct imaginaries of an investment hiatus, leading to the possibility of future power cuts and blackouts, and a need for guaranteed prices.

1. Introduction

Much of the Investment Appraisal (IA) literature conforms to (Northcott (1991):221) observation that Discounted Cash Flow (DCF)[1] concepts proceeded from economic literature, conveying many of the basic premises of neo-classical theory. Economic literature introduces notions of economic efficiency and shareholder wealth maximization, which are embedded in a normative context of economic formalism and instrumentalism (Çalışkan & Callon, 2009). We argue that models of investment, such as DCF and Net Present Value (NPV), should not be perceived as purely passive calculative techniques. Accounting models such as DCF, can "do things" not just fulfilling the conventional prescriptive role of assisting human actors to make investment decisions, but also helping 'to create and distribute Homo Economicus… ' as ' … economic agents result [ing] from the framing and distribution of calculative agencies' (Vosselman, 2014, p. 184). Yet the argument presented here is not merely that human ontologies can be changed but 'that calculation and noncalculation reside not primarily within human subjects but in material arrangements, systems of measurement, and methods of displacement - or their absence' (Callon & Law, 2005, p. 718). In this sense, the IA model is itself an actor and 'rather than representing reality, directly intervenes to construct the reality it purports to describe … ' (Cushen, 2013, p. 316).

We develop these performative aspects of IA models (Doganova & Eyquem-Renault, 2009) in the empirical context of negotiations about the construction of new electricity generating plants (known generally as Power Stations). Just as Callon (1998a; 2007) and MacKenzie (2007) have shown how a model such as the Black-Scholes formula can help make derivative markets; *our submission is that the NPV/DCF model can frame public policy debates in a particular way.* Our specific public policy concerns relate to negotiations around the regulation of the electricity generation industry. Such negotiations *could* draw on diverse perspectives, such as: scientific, engineering, political, and regulatory. Although significant negotiations centre on economic concepts (Hoffmann, 2007), we argue that an economic focus is not inevitable, but rather arises from processes of economization (Çalışkan & Callon, 2009), marketization (Çalışkan & Callon, 2010), and financialization (Cushen, 2013) supported by various human and non-human actors. We argue that IA models, especially DCF/NPV, provide a common frame of reference for negotiators, driving the financialization process and

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[1] DCF means Discounted Cash-Flow and is used interchangeably with Net Present Value (NPV).

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promoting a neo-liberal approach. Throughout this process, issues of sustainability and security of supply are subsumed into a financialized discourse or *agencement* (Callon, 2007), framed by accounting calculations and financial rates of return.

Elaborating on MacKenzie's 'conditions of felicity' (2007:69), we analyze the cultural, political and economic circumstances in which the performativity of DCF/NPV is likely to be enhanced, and other situations when counter performativity or misfires occur. We propose an alternative political economy theory that recognizes the performative aspects of economic and accounting models, but which locates them in critical and reflexive frames. Hereby, we seek to reconnect economics and politics around performativity, to develop performativity as politics, 'to help reinforce political analysis of markets and market-making … ' (Cochoy, Giraudeau, & McFall, 2010, p. 141). In particular, we draw on the concept of imaginaries, as developed by the theory of Cultural Political Economy (CPE) (Jessop & Sum, 2016; Sum, 2012). We demonstrate that the electricity market in Great Britain (GB) has been subject to ongoing experimentation (Callon, 2009), arising from the construction of different *imaginaries*. Developing the negotiating role of IA models, we argue that the generators have posited a future imaginary of blackouts and power cuts, proceeding from a failure to invest in new generating capacity. In essence, the generators mobilized IA models as rhetorical devices in policy negotiations with the GB government. By analyzing the outcomes of these negotiations, we evaluate the extent to which they can be attributed to the performative role of IA models.

In order to set out its theoretical and methodological foundations, the paper proceeds with a selective review of the literature on performativity, particularly concentrating on capital budgeting and the electricity generation industry. It then proceeds to use CPE theory to interpret original fieldwork. Finally, drawing on the theory and the empirics, the paper discusses capital budgeting practices in relation to complex electricity generation negotiating scenarios.

2. A performative perspective on IA models - framing, spillovers and calculative practices

This section grounds our performative perspective in IA models drawn from the wider literature on economization, marketization, financialization and calculative practices. It argues that IA models can play a role in framing all these processes, but also acknowledges that such framing is inevitably accompanied by spillovers that confound attempts to de-politicize (Callon, 2010) issues such as energy generation. Then, building on an emerging literature on critical performativity (Cabantous, Gond, Harding, & Learmonth, 2016; Spicer, Alvesson, & Kärreman, 2009; Wickert & Schaefer, 2015), we discuss alternative political economy theories that recognize the performative aspects of economic and accounting models, but which locate them in critical and reflexive frames.

From the outset of this review, we are indebted to Callon's insights concerning the performativity of economic theories, as they offer the broadest concept and frame (see Fig. 1, Callon, 1998a; 1998b; 2007; 2010). Callon argues that economic theories not only intend to represent reality but that, 'economics, with the multiplicity of frames of analysis and theoretical models that it develops, contributes to the constitution of the object that it studies' (2010:163). Elaborating on the performativity of economics, Çalışkan and Callon (2009) identify processes of economization, which denote 'the processes that constitute the behaviours, organizations, institutions and, more generally, the objects in a particular society which are tentatively and often controversially qualified, by scholars and/or lay people, as "economic"' (p.370). Economization processes proceed from a broad definition of 'economics at large', which includes other disciplines and practices, including accounting (Vosselman, 2014). In the specific context of this paper, the economizing framework identifies the problem of electricity supply as a question of economics, rather than conceiving of it as a scientific, engineering or political issue.

The economizing frame can be further narrowed through a process of marketization (Çalışkan & Callon, 2009; 2010). Çalışkan and Callon (2010) argue that markets 'delimit and construct a space of confrontation and power struggles … ', creating spaces in which, ' … (M)ultiple contradictory definitions and valuations of goods as well as agents oppose one another in markets until the terms of the transaction are peacefully determined by pricing mechanisms' (p.3). The next, and even narrower, frame involves processes of financialization, increasing the importance of financial actors and calculative devices both within and between organizations (Cushen, 2013; Vosselman, 2014).

Financialization elevates the particular performative role of accounting, as accounting calculative models traditionally privilege shareholder interests. The financial orientation is particularly strong in DCF, which purports to connect internal decisions on investments with interests of external investors. Indeed, finance theory argues that firms can be viewed as bundles of projects, with their total value determined by the sum of their DCFs (Copeland, Weston, & Shastri, 2004). From a performativity perspective, it can be argued that financial theories such as NPV, 'are actualized' as long as the 'conditions of felicity' (Callon, 2007, p. 321) are fulfilled. Some key conditions of felicity for the DCF model are the same as those supporting the Black-Scholes formula; namely, a dominant belief in the efficient markets hypothesis and ' … a political culture in which economics was a useful source of legitimacy' (MacKenzie, 2007, p. 70). MacKenzie also mentions specific institutional and material changes which enabled the Black-Scholes formula to appear 'less unrealistic' (2007: 74). For example, short selling became more practical when institutional investors, such as pension funds, were prepared to lend their stock and when the New York stock exchange introduced stock-index futures. As becomes apparent later in our elaboration of CPE, the pro-market, neoliberal institutions of the recent privatization era were part of a wider neoliberal political culture. In the different political culture which was the pre-privatization period, DCF was less closely linked to financial and marketized frames. With the generating industry in GB under public ownership, DCF was promoted as the "correct" investment model, because it prompted decisions that might increase national economic growth (Miller, 1991) rather than maximize shareholder wealth, as supposed under neoclassical finance theory. In short, material and institutional factors can sometimes reinforce semantic and discursive factors,[2] whilst at other times, such as times of crisis, they may act against them.

Fig. 1 illustrates the relationships between these frames. Moving from the macro-level of economization into the more micro-levels of marketization, financialization and calculation, the arrows emphasize that frames are in recursive and reciprocal relationships. Although the calculation of NPV/DCF combines a myriad of issues, reducing them to a single figure (Miller, 2001), the model affects the more macro-levels of markets, the wider economy, and, as we shall argue below, the political and regulatory spheres.

2.1. The DCF and the mediation of negotiations between actors in the electricity industry

One of the strengths of the performativity thesis is that rather than viewing accounting as fulfilling merely a symbolic role in

[2] We are grateful to an anonymous reviewer for raising this point.

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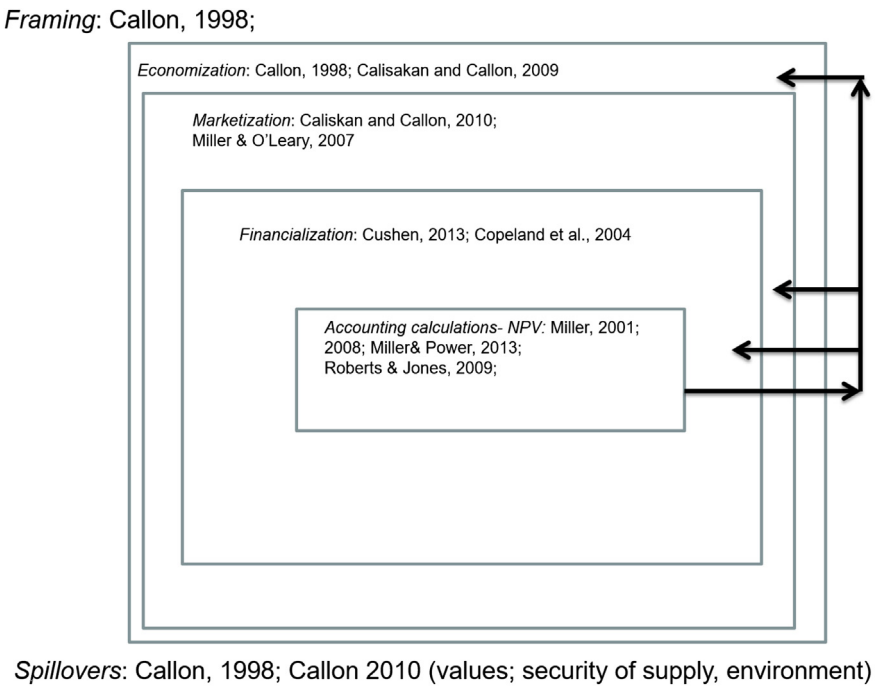

Fig. 1. Framing and spillovers: economization, marketization and financialization.

which specific calculative features are relatively unimportant, the technical characteristics of a model such as NPV/DCF are important in enabling it to "do things". Whilst the conventional prescriptive role of these models is to evaluate choices between well-structured investment alternatives, in a *negotiating* context, the technical characteristics of the models help it achieve other objectives, such as framing the way that alternatives are presented. For example, one of the useful technical features of the DCF model in a negotiating context, is that, while 'the contents of the DCF formula seem to be extremely flexible, its structure appears rigidly robust' (Doganova, 2011, p. 13). Thus, different assumptions about technology and pricing levels can all be modelled to ensure understanding from all players. Furthermore, the various forms of the DCF offer a single figure incorporating the relationship between costs and revenues (profit), and introducing a *time* value for money and cost of capital to capture businesses' financial *risks*. Miller (2001) emphasizes the 'elegance of the single figure' (p.382) by arguing that 'net present value calculations sought to render the future, knowable, calculable, and amenable to control' (p.391). Similarly, Bowman et al. (2014) explain the influence of the 'point value principle' enshrined in the discounting calculation:

> The techniques now taught as discounted cash flow offer a way of converting any future stream of payments over time into a 'point value' in the present … the future is converted into the present through algebra which requires only the inputs of estimated cash flows and an appropriate discount rate … (p.124)

The performativity thesis suggests that some of the technical criticisms of DCF underestimate its practical relevance as a business model. For example, (Doganova and Eyquem-Renault (2009):1559) note that 'puzzlement' might arise from the fact that, 'whilst cogent analysis from management science tends to debunk the calculative power of the business model, investors and entrepreneurs continue to consider it a key ingredient of their economic endeavours'. Doganova and Eyquem-Renault (2009) contend that whilst business models may appear flawed to academic critics, they play a central role as 'market devices', serving the creation of current and future economic realities (Callon, Millo, & Muniesa, 2007).

In this paper, the key business model associated with the future reality of the regulated electricity market is the DCF model. It is used as a valuation device, assisting in the construction of a shared reality for all the human players responsible for negotiating on environmental issues and regulated price-setting. Yet, as Vosselman explains, an accounting device such as the DCF is more than just 'a re-presentation of reality, it also mediates between actants in a network'; ' … it shapes who and what counts and '(A)s an actant, the 'presence' manufactured by accounting is symmetrical to human actors; it has material agency' (p. 183). Dugdale (1999) argues that traditional analysis of negotiations focus on interests and power, but fail to explain how power is mobilized through aspects of *practical materiality*. To her examples of committees drinking coffee and shuffling papers, we would add the material agency of calculative practices, such as financial models. In the negotiations analyzed here, the NPV model performs a mediating role linking science (climate change and engineering), the economy (Doganova, 2011; Doganova & Eyquem-Renault, 2009; Miller & O'Leary, 2007) and firms to political programmes (Miller, 1991). As Miller puts it:

> If figures are intrinsically linked to programmes, and if they can transform the domains that they represent and act upon, then the single financial figure is a technology of intervention par excellence (Miller 1994b; as cited in Miller, 2008). For the single financial figure not only accords objectivity and neutrality, it makes comparable activities and processes that may otherwise have little in common. The single financial figure, as produced by the calculative routines of accounting, can link up agents and activities into a functioning calculative and programmatic ensemble (Miller, 2008, pp57-58).

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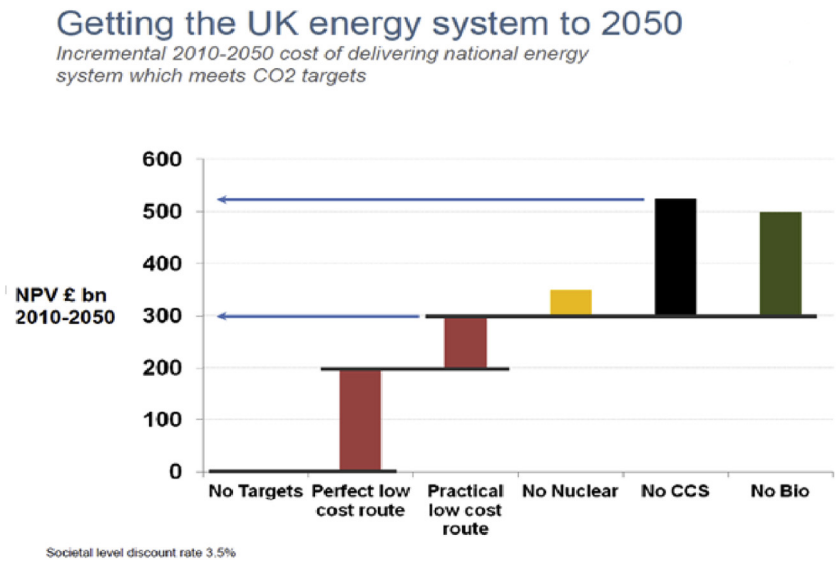

Fig. 2. Think tanks modelling environmental targets within engineering knowledge (Heaton, 2017).

An example of the practical materiality of the NPV figure is given in figure two, which demonstrates how a think tank has compared electricity generating policy options based on different generating technologies (e.g. no nuclear versus carbon capture). Significantly, the economic costs of each policy option were compared through the calculation of a single NPV figure, based on a specified social discount rate. Thus, it is possible to observe the practical materiality (Dugdale, 1999) of the DCF/NPV model as it mediates science and the economy by drawing on a combination of sciences (engineering and climate), and calculating their economic consequences through a model more commonly used to calculate shareholder returns.

As we argued above, the concepts of framing and performativity do not imply that a model such as DCF/NPV can create markets out of nothing. Rather such models *actualize* rather than create (Callon, 2007), with the performative and re-presentational properties of a financial model intertwined in socio-material networks (MacKenzie, 2007; Vosselman, 2014). As discussed earlier, the actualization of a particular reality depends on a combination of discursive and material factors. In order to elaborate on this 'material-discursive making of the world' (Nyberg & Wright, 2016, p. 618), we avoid the traditional sociological perspective on institutions (Latour, 2005; Modell, Vinnari, & Lukka, 2017). Instead we follow Callon (2007), who proposes the concept of socio-technical *agencements.* If a socio-technical *agencement* is 'a combination of heterogeneous elements that have been carefully adjusted to one another' (Callon, 2007, p. 319) then, in our context, an excellent example of how an institution may be re-cast as a socio-technical *agencement* is the university think tank. As shown in Fig. 2, a university based think tank, based in an engineering department, can deploy the NPV model as a way of comparing the economic impacts of alternative technologies. These economic experiments also unite other materialities, such as knowledge drawn from engineering and climate science, which are the sources of the various policy options. Such think tanks do not just emerge by chance in a political and policy vacuum. Rather, technical and financial support for these institutions was obtained from industry actors, notably some of the generators, who, as we show later, have very specific financial interests at stake in the outcomes of these policy experiments (Callon, 2010).

2.2. Framing, spillovers, mis-fires and counter-performativity

Thus far in our review of the performativity thesis, we have emphasized how economic and accounting models might act as framing devices, particularly when felicitous conditions prevail (Callon, 2007). We might anticipate that just as the performative impact of the DCF model may prejudice negotiations towards neoliberal, minimalist state type solutions, the model will find that felicitous conditions are likely to abound when political programmes are already pre-disposed towards neoliberal economic policies. Yet even under these conditions, there are limits to performativity characterized by spillovers (Callon, 2007) or counter-performativity (MacKenzie, 2007). Indeed, spillovers are just as significant as frames; one is the by-product of the other (Callon, 1998a). Overflows are inevitable, because 'moments of overflow mark the emergence of a frame's shortcomings, and in so doing make material, legal or other framing devices visible while inspiring debates on how these might be improved' (Çalışkan & Callon, 2010, p. 8).[3]

The role of framing and spillovers has been researched in relation to environmental regulation, carbon markets and re-cycling (Callon, 2009; Gregson, Watkins, & Calestani, 2013; Lohmann, 2009; MacKenzie, 2009). Researchers have identified the role of specific calculative devices, such as ship assaying (Gregson et al., 2013), the role of experiments in the design of markets (Callon, 2009), the role of cost-benefit, carbon accounting techniques (Lohmann, 2009), and the possibility of a 'politics of market design' (MacKenzie, 2009). Discussing the debate concerning the 'distribution between politics and economics' (Callon, 2010, p. 164), Callon uses the example of climate change programmes to illustrate the diversity of policy proposals, some of which use the carbon markets, and others that reject market solutions entirely (Lohmann, 2009).

The performativity of economic theory and accounting need not be analyzed solely in terms of the neoclassical model and neoliberal

[3] For example, the prices contractually agreed in the contract to construct Hinckley point nuclear power station are now so high and out of line with prices of alternative energy sources that even pro-market commentators are beginning to question a private sector approach to the project (Jeremy Warner, DT, August 2017).

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political economy. Indeed, Callon (2010) argues that, given the diversity of economic theories, performativity allows differing conceptualizations of the relationship between economics and politics. For example, traditional political economy theory implies economic actors are embedded in social and institutional arrangements (Çalışkan & Callon, 2009; 2010). Similarly, Miller (2008) explains how, in the political economy of accounting, accounting is 'viewed as a partial and interested language and practice, representing particular occupational groups and classes' (p.55). When performativity is informed by the political economy approach it can also develop a critical perspective on calculating devices by studying the relations of domination, as Çalışkan and Callon point out, '(I)nequalities derive from the unequal power of calculating agencies that loop back to reinforce themselves' (2010:13). Proposing a progressive view of performativity within the critical management tradition, Fleming and Banerjee argue that '(W)ithout a wider political analysis of organizations, institutions and markets, the capacity to perform economic rationality differently will be limited, which in turn restricts the scope for politics, political subjectivity and dialogue … ' (2016:263).

3. Developing theory and methodology: CPE and the concept of imaginaries

Critical accounting theory can reveal the historically contingent and contested nature of DCF. For example, Miller (1991) illustrated how, in an historical context, the role of DCF in industries such as the electricity generation was both contested and linked to broader concerns of national economic growth. Building on this seminal contribution with an analysis of energy policy based on cultural political economy (CPE) (Jessop, 2013; Jessop & Sum, 2016; Sum, 2012), we propose developing a critical performativity approach, which can be applied to both historical and recent developments in investment decision making in the GB electricity industry. The ontological and epistemological approach of CPE is entirely consistent with performativity, as the concept of the *imaginary* offers a way to study the links between the performativity of the DCF model within the context of the major structural relationships that characterize state-market relations (Sum, 2012).

In their exposition of CPE, Jessop and Sum (2016) argue that social life is only possible because actors simplify reality by drawing on imaginaries, as 'clusters of meaning' (p.107). Focusing on ontology, CPE embodies the view that since the world is complex, social agents 'must reduce complexity by selectively attributing meaning to some of its features rather than others' (Jessop, 2013, p. 3). These agents draw on what Jessop (2010; 2013) terms *imaginaries*. An imaginary is 'a semiotic ensemble (without tightly defined boundaries) that frames individual subjects' lived experience of an inordinately complex world and/or guides collective calculation about that world' (Jessop, 2013, p. 4). Imaginaries can have different applications; for example, highlighting generators' *economic* imaginaries. (Jessop (2013)):4) explains economic imaginaries below:

> Economic imaginaries have a crucial constitutive role here insofar as they identify, privilege, and seek to stabilize some economic activities from the totality of economic relations. They give meaning and shape thereby to the 'economic' field but are always selectively defined.

Whilst other actors responsible for influencing investment decisions also draw on imaginaries, they might place lesser emphasis on economic elements. For example, Levy and Spicer (2013) propose four possible climate change imaginaries: 'fossil fuels forever', 'climate apocalypse', 'techno-market' and 'sustainable lifestyles'. They also suggest the techno-market imaginary proved particularly influential up to the economic crisis of the mid-2000s, as they describe this imaginary as optimistic and pro-market:

> … based on advanced clean energy technologies such as solar and wind alongside carbon trading and other market innovations. The invocation of innovation, entrepreneurship, venture capital and carbon markets allocates a primary role to the private sector in addressing climate change, lending this imaginary a broad appeal across multiple constituencies … (Levy & Spicer, 2013:664)

The techno-market imaginary is also compatible with some components of regulation and state intervention, as long as the fundamental tenets of the capitalist market are respected. For example, an imaginary that supposes a form of Green Keynesianism (Levy & Spicer, 2013) can easily accommodate an IA discourse on "correct" long term social discount rates (Arrow et al., 2012) and the various carbon reduction options compared in Fig. 2.

Building on our earlier discussion of framing, practical materialities, and negotiation, we submit that an accounting calculation such as DCF can play an important mediating role in the creation of a particular economic imaginary. We also perceive that opportunities for the DCF model can be used *strategically* to frame negotiations between different industry players. More specifically, as shown in Fig. 3, the generators can mobilize the DCF model to construct an imaginary with a very simple logic; that is, negative NPVs result in no new investment, creating possibilities of power-cuts and black-outs.

The DCF model privileges particular aspects of economic activity, such as cash flows, risks and discount rates. This disaggregation is illustrated in Fig. 3, which shows how the required return might be achieved through interventions at a number of points, which themselves might be expected to feature in negotiations between private generators seeking required returns and government regulators. For example, costs (negative cash flows) could be affected by regulations requiring specific technologies in order to meet pollution targets. Discount rates can be affected by the perceived risk of investments calculated on the basis of cash flows underpinned by a particular set of price curves.[4] The message of the model is clear; if the GB government aims to guarantee supply and meet environmental targets, then, in a market context, it must use pricing mechanisms to incentivize those private generators who demand positive NPVs. The model in Fig. 3 is *intentionally* very simple: it does not capture issues of uncertainty, the strategies of multinational companies, or explain how a discourse involving DCF can trap negotiators and rule out non-market oriented imaginaries. Nevertheless, by casting negotiation problems in terms of a standard NPV model comprised of revenues (positive cash flows), costs (negative cash flows), and discount rates, a narrative based on the NPV model is characterized by hegemonic financialization rhetoric (Froud, Johal, Leaver, & Williams, 2006; Erturk, Froud, Johal, Leaver, & Williams, 2008; Cushen, 2013). Furthermore, the shared meaning provided by the DCF model suggests other players might struggle to construct an alternative economic imaginary distinct from the formalist model of DCF, with all the marketization and financialization implications reviewed earlier.

Whilst helping to reveal potential policy bias arising from imaginaries shaped by neoclassical theories of economics, CPE enables radical and critical developments in performativity studies (Cabantous et al., 2016; Spicer et al., 2009; Wickert & Schaefer,

[4] As will be shown subsequently, the industry tends to use 'price curves' in their models rather than single equilibrium prices.

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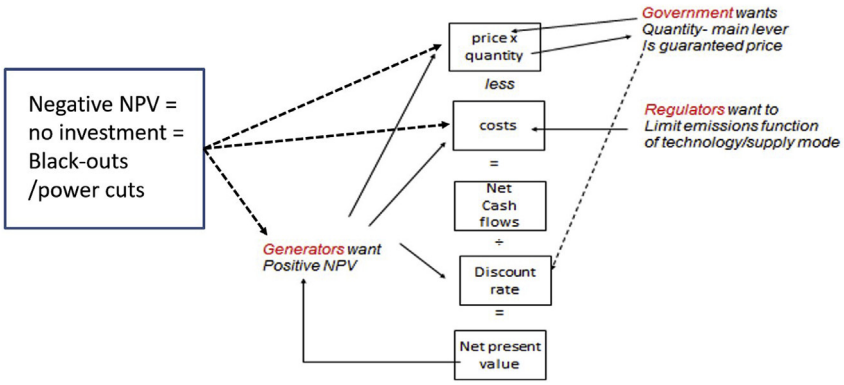

Fig. 3. How the DCF model helped to constitute the generators' negotiating imaginary.

2015) by offering alternatives to those frames that support neoliberal solutions to environmental issues. An additional strength of CPE is that it can explain the variation, selection and retention of particular imaginaries. Although imaginaries have considerable stability, they can be challenged during crises that loosen sedimentary social relations, allowing semiotic variations and the possibility of novel solutions. In the UK, regulators and other policy makers have, since the end of the 1970s, framed regulations relative to an imaginary of competition and markets (Bowman et al., 2014; Thomas, 2016). Thus, it seems pertinent to ask: what sort of crisis might change this imaginary? More specifically, will the possibility of power cuts and blackouts constitute a sufficiently severe threat to result in the abandonment of the competitive market imaginary? To many, the possibility of electricity outages/blackouts constitutes a crisis. However, blackouts have occurred in the USA without prompting significant changes in the ownership or mode of electricity generation. Indeed, as (Roubini and Mihm (2011), p. 38) point out, there are a multitude of views amongst economists as to what constitutes a crisis:

> Ask economists why booms and busts occur, and you'll get a wide range of responses. Some will tell you that crises are inevitable consequences of government meddling in markets; others will maintain they occur because government didn't meddle enough. Still others will claim that there is no such thing as a bubble: markets are perfectly efficient.

In a CPE framework, it is possible to define crises through the criteria of political economy; capitalist owners define crisis, not in terms of blackouts (i.e. a problem for their customers), but rather in terms of threats to private ownership and/or falling profits. But the CPE framework also suggests that the notion of a crisis can be constructed by imaginatively combining data and DCF models.

In summary, the relationship between CPE and performativity is one of mutual complementarity. In CPE, there is a neglect of aspects of practical materiality with which to analyze the micro-processes of negotiation and power mobilization. Yet, in its favour, CPE places more emphasis on structural relations, which provides the context within which negotiations take place. For example, as we explain below in our empirical analysis of the GB electricity industry, we do not argue that the DCF model performed the structural move from nationalization to privatization. Yet, once that switch had taken place, we submit that the DCF model framed negotiations and reinforced neoliberal solutions. In terms of our empirical interpretation, CPE is a useful way of explaining either actual or potential changes in relations and is ontologically and epistemologically reconcilable with the performativity analysis of detailed negotiations within a privatized context.

4. The GB electricity industry: An historical and field analysis

Before the case study is presented it is important to understand the context of the industry. GB's electricity industry can be analyzed in three parts: 1) The generation market (the power stations); 2) infrastructure; and 3) the supply market (the retailers). Currently, electricity companies can own just two of those segments: generation and retail; an independent company (National Grid) owns the infrastructure. Whilst the retail side of the industry has been heavily regulated, the ownership of the generators, who have had primary responsibility for investment decisions, was largely unregulated.[5] Focusing on the power generating sector of the industry, the fieldwork presented in the following sections traces the course of negotiations between GB generators and the government, as represented by the main regulators: the Department[6] for Business, Energy and Industrial Strategy (DBEIS) and the Office for Gas and Electricity Markets (Ofgem). The empirical evidence demonstrates that throughout successive market designs (Callon, 2009), the DCF model framed the economic imaginary of investment at all levels: the plant, the company, the regulator and even at the supranational level of the EU. During the detailed case study period (2006–2017), the industry operated under the British Electricity Trading and Transmission Arrangements (BETTA), which was a fully open market, imposing minimal restriction on the buying and selling of ownership in electricity companies. Generators traded electricity through a variety of bilateral and multilateral contracts. However, against the backdrop of increased environmental regulation, subsidies for investment in certain technologies destabilized the pure market concept. Government interventions to combat climate change created spillover effects; tensions between the climate change agenda and seeking profit resulted in new market structures for investment, as will be observed later in this case study.

By the first quarter of 2017, the big six energy generators dominated 83% of the supply market (Ofgem, 2017). At this time, stringent international standards on pollution and carbon production were imposed by the Department of Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA). Although

[5] Apart from general regulations based around competition rules.

[6] The regulators prior to June 2016 sat within the Department of Energy and Climate Change (DECC).

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the revised Large Combustion Plant Directive's (LCPD) directive, introduced to reduce Nitrogen (NO_2), sulphur dioxide (SO_2) and particulates, was the main regulatory context of the case study, other regulatory efforts[7] also played a role.

4.1. Methods and sources

The case study that follows is split into two main phases. The basis for this split is partly the changing economic and political cultures or 'conditions of felicity' (MacKenzie, 2007) and partly the different sources of data. Thus, the first phase of the historical narrative draws on secondary data to understand the use of DCF/NPV in the electricity generating industry both prior to privatization and in the post-privatization period up to 2006. The second phase of the study draws on original fieldwork and other primary sources, and begins with the debates and negotiations leading up to decisions concerning whether companies would opt in or out of the LCPD during 2006–2008.

The fieldwork described in this paper was specifically designed to investigate the investment decision-making processes applied within GB's electricity generation industry with a particular focus on the possible impact of the revised LCPD. The main data collection was longitudinal in nature and was undertaken over a six-year[8] (2006–2012) period. Various organizations were consulted, including five of the big six generators. Each narrative was collected using semi-structured interviews, which were audiotaped and transcribed. Whilst the questions used in each interview were structured around three themes, considerations of the role of the actor sometimes resulted in modifications. The three themes were: 1) communication regarding investment decisions; 2) social, political and economic factors influencing investment decisions; and 3) resourcing, communication and power relations in the investment process.

Fourteen interviewees contributed the data for the original study, and, in 2016, three additional interviews were conducted to collect industry perceptions regarding recent developments. Many of the interviewees were interviewed repeatedly. In addition, a business plan applied in the decision-making process was also used as a data description tool, alongside consultants' responses to reforms in 2016/17. The interviewees included all stakeholders: generators, regulators, financial analysts and consultants, facilitating representation of the imaginaries of all those involved in the decision-making process. Further material data included shareholder reports and White Papers, and views collected at annual industry conferences to debate future policy and needs, attended by government ministers and the CEOs of the generators and regulators. In short, data collections included both human actors and non-human actors, as well as evidence such as presentations and networking activities, which could be seen as aspects of material practicality (Dugdale, 1999).

4.2. Phase 1: pre-privatization through to 2006

The GB's electricity generation industry can best be understood relative to the type of assets it holds, and the market structures that govern it. Significantly, power stations have long lives, and current industry assets have survived many changes in government. In particular, much of the generating capacity available today originates from the pre-privatization era (Jupe, 2012; Warren, 2014; Warren, Kristandl, & Quinn, 2018); a time when decisions on particular power stations could be framed by political concerns, such as maintaining employment in the deep coal mining industry. As Miller (1991) pointed out, DCF was promoted as a calculative device in the government's economic imaginary during the 1960s, but as part of an interventionist, rather than a neoliberal, pro-market, economic policy. In an era which espoused indicative national economic planning, DCF was promoted as an appropriate technique for investment appraisal in both the private and public sectors, stemming from the belief that it would encourage good quality investment and enhance national economic growth. In short, investment decisions marking the pre-privatization phase, when much of the current generating capacity was constructed, were influenced by quite different socioeconomic agencements.

As part of the pro-market neoliberal programme of the Thatcher government (which was informed by academic economists with Austrian leanings[9]), the industry was privatized in 1990. After privatization, significant changes occurred affecting the market structure, with a competition oriented regulatory focus applied to the GB's generation market (Bowman et al., 2014; Littlechild, 2014; Thomas, 2016; Warren et al., 2018). The period 1991–2001 is recorded as a very profitable phase for the industry. Several of the interviewees who worked during this decade explained that following privatization, business reports became more structured around shareholders' needs. Thus the use of the DCF model became formalized as part of the decision making process and rates of return were seen as a critical piece of information, informing investment decisions. At this time profits were easier to achieve because *every* generator would receive the highest price offered by the National Grid. Finally, it is important to note that in this period investment decisions were not significantly influenced by environmental regulations (Warren et al., 2018).

Overall, it seems that the performative role of the DCF model was particularly uneven in the early phases of our historical review, due to the 'conditions of felicity' (Callon, 2007), which varied during different historical periods. We have schematically summarized the main historical events and factors that affected investment processes in a timeline (see Fig. 5). This also indicates the differing degrees and types of performativity associated with the DCF/NPV model, as the composition of the networks in terms of human and non-human membership and relationships changed. Whilst the earlier phases of the historical review up to 2006 are based mainly on secondary sources (Miller, 1991; Warren et al., 2018), the evidence on investment imaginaries in the period (2006–2016) is based on detailed and original fieldwork, as presented below.

By 2006, although new sanctions were in place for those generators failing to comply with the LCPD, the GB government expected to meet environmental protection targets whilst maintaining its ideological commitment to a free market, privatized industry. This spillover effect was recognized by the generators whose own imaginary revealed the unprofitability of new investments (see Fig. 2) and predicted that without a change in policy future supplies of electricity were insecure. As we shall see below, the tensions between security of supply and regulations for environmental protection within a privatized industry, gave the generators an opportunity to lobby for policy changes that virtually guaranteed "acceptable" rates of return.

[7] Related to concerns about carbon emissions and their possible impact on global warming. For example, the EU implemented an EU European Emission Trading scheme, to which all the electricity industries across Europe are subject.

[8] See Appendix 1 for a detailed explanation of method and data collection.

[9] In particular, the Director General of Electricity Supply (1989–98) was Professor Stephen Littlechild.

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4.3. Phase 2: 2006–2008 the LCPD: conflicting imaginaries and opportunities for mediation

During the 2000s, environmental regulations became more voluminous and influential, including the revised LCPD. The revised LCPD was introduced to reduce emissions by targeting combustion plants with a thermal capacity of 50 MW or greater. This regulation was applied to coal power stations, oil refineries and steel works. With stringent emissions limits, each operator was given the choice whether to opt in or opt out of the directive. In the case of electricity generators this meant all coal and oil plants had to decide whether to invest in the relevant technology to reduce emissions (known as *opting in*) or to close after a further 20,000 hrs of operating (known as *opting out*).

From the generators' perspective, it was unclear what technologies and fuels the government would support and what market mechanisms would be put in place. The concern over technology and fuel was exacerbated at the time of the interviews, because two EU governments made unexpected and retrospective changes to the regulations within their own countries. Germany announced a nuclear tax regime, which was predicted to amount to around £12bn over five years and Spain retrospectively withdrew solar subsidies, after previously offering to encourage renewables (Citigroup, 2010). One Station Manager claimed:

> We were trying to get a good indication from the Government on what was going to be *policy, going forward*, you know you need them when you're investing for thirty years and spending hundreds of millions on them. There were *no clear economic signals from the Government* and when you actually looked at FGD at Plant B at the time it was hard to determine whether you're making the right business decision for the shareholders.

With the Head of Generation, UK, adding:

> We need clarity from the government on what they want from us. At the moment we are all looking into nuclear … a few plots of land that are really worth half a million have just been sold for two hundred and sixty million because there are limited sites with a chance to build nuclear on. But the prices just don't support nuclear yet, this is not an efficient way of doing things. It would be better to organize who the players are who can do this, divide the land, give them the costs and let them get on with it, but there is nothing! … there is a gap at the moment, there's a disconnect between pricing and the ambitions of the UK Government.

In addition, an Environmental Manager stated:

> You know you're not going to be making an investment if you're not getting a *return on that investment* … there are a number of factors that need to be taken into account. But effectively an IA would be made on the technology that's required to meet the *particular limit* … you know that if it didn't meet the *required rate* then you know it's unlikely to go forward (emphasis, added).

The generators clearly wanted guaranteed prices that would underwrite their financial returns. As Head of Coal operations explained:

> We are expecting the government to pay some capacity payment or availability payments, they can't keep going on the way that they are – *the market is not working, and our modelling shows this*. Secure prices will encourage new investment. (emphasis added.)

4.4. The practical materiality of IA modelling in business planning and negotiating for the LCPD

The quotations in the previous section indicate that the generators aimed to influence the regulations in two aspects; reduced policy uncertainty with respect to approved technologies and guaranteed, rather than free market prices. In order to achieve these objectives, the generators were able to deploy practical materialities (Dugdale, 1999) to support the imaginary set out in Fig. 3: namely, their specialist engineering knowledge and the consistent application of IA models as a way of linking economic and environmental issues. With respect to deploying their specialist engineering knowledge, the consultations for the revised LCPD presented generators with an invaluable opportunity to influence a new regulatory framework directly as new rules on specified environmental emissions targets were drawn up only after discussions between shareholders, regulators, and professional bodies. This process was one of trial and error, as all parties modelled the changes and the impacts they would have if changes to the regulations were made. Recognizing that the regulators could benefit from the generators' technical knowledge, it became standard practice for firms to work alongside them, to avoid policy disrupting conflicts and disagreements (Sarasini, 2013). As one Environmental Manager noted:

> We had meetings with Defra and meetings with the EA through our JEP[10] forum. We sat around a table and tried to understand it. What does it mean when it says that you will meet this limit on sulphur? But you have this option to do it in a slightly different way. What are these time scales on monitoring? How can we interpret that in terms of something the EA can transform into a permit that we can carry out?

The practical materiality of the DCF/NPV model was evident in performing a mediating role in both the *internal decision making* of the generators (linking environmental issues with financial returns) and in *negotiations* with the regulators. In the latter case, the NPV model showed the link between the capital spend of the generators and government programmes. The generators embedded well-known IA techniques within more complex business plan models, capturing the impact of the regulatory changes. The NPV model was intrinsic to the internal modelling of environmental regulation, because as an executive who had responsibility for corporate regulation put it:

> When there is a lot of risk involved, especially with environmental regulation changes, we sometimes measure it as an option but that is using all the fundamentals of NPV. The volatility in the profitability due to the pricing sometimes means we are looking for intrinsic values to provide us with the confidence that we should go ahead.

The twin performative aspects of the NPV model in both internal decision making and external negotiations were expressed as follows:

> NPV is the traditional method we use when looking at any investments and also when deciding how to lobby for change, we use this with the regulators through our published responses and with Treasury when we are acting as kind of consultants to demonstrate things to them. However, that said, we do not show them our workings because that is confidential. We may show

[10] Joint Engineering Project (JEP).

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them the outcomes when we are analyzing different technologies or changes in the energy market framework.

These twin aspects of negotiations *within* the companies and *outside* with public policy makers were illustrated when an interviewee who acted as a lobbyist described the company's rhetorical tactics:

> We comment on National Grid's analysis, but you can imagine that they are well placed to analyze the entire system and weigh up risks. (But) … in our discussions with stakeholders we may comment on investor confidence based on policy uncertainty, or, in the extremes, the possible effects of introducing poor policy design. However, the discussions are more likely to be related to the cost of capital of projects, rather than the threat of a lights out situation. We try to be politically sensitive but our message is clear.

In short, whilst showing due respect for the knowledge of the whole system possessed by the organizations responsible for the national electricity network, the lobbyist communicated the links between 'poor' public policy and private shareholder concerns. Although they avoided crass mobilization of the blackout threat, the lobbyist was confident that significant players like National Grid "got the message".

Although firms did not make their business models fully available, the researchers were able to access the business plans for one investment, which showed the routine use of the DCF model for investment decision making. The business plan is an example of the material content used as part of the investment decision making process. In the particular extract from the business plan in station A[11] shown in Exhibit 1, rules concerning the LCPD apparently created so much uncertainty that many of the generators originally chose to opt out.

Interview evidence confirmed the impact of regulatory changes on investment viability. A Business Services Manager stated:

> For a long time it looked like the FGD, for the LCPD, was not an investment we wanted to make … but quite interestingly the *rules on carbon changed* and that's what swung the pendulum back in favour of the investment … at the last second, we decided to opt in. A guy suddenly realized that the changes *made the models go from red to black*. (emphasis added.)

Although this above quotation seems to imply the rule changes were just a "lucky coincidence", Station A's original decision to opt out strengthened the generators' hand when lobbying the regulators. In this interpretation, regulatory decisions were adapted as an outcome of successful negotiating tactics (i.e. an investment strike). A further extract from the business plan shown in Exhibit 2 explains the evolution of a more favourable investment climate.

The business plans submitted to the board were presented as modelling outcomes, as demonstrated in Exhibit 3. The NPV recalculation reveals how the change in carbon policy improved the

The strategic advantages in being able to retain full use of coal plant up to 2015 and beyond have consistently been recognised but the business economics have been too poor to date to support a recommendation to invest in FGD and opt-in. In June 2004, therefore, Station A opted-out from the main provisions of the LCPD and this decision was confirmed in November 2005 by the Board based on an economic valuation that showed a negative NPV of £129m. At that stage, the LCPD opt-in decision deadline for generators was 31st December 2005.

Exhibit 1. Opting out early in the decision-making process (Source: Business Plan from one of the big six).

Since 2004, there have been the following significant changes:

a) LCPD opt-in decision deadline was pushed back to 3 February 2006.
b) The Department of Trade and Industry (DTI) has indicated that under Phase II of the EU Emissions Trading Scheme (ETS) opted-out plant will receive a free carbon allocation commensurate with running at a load factor of 28% (a level in keeping with the 20,000 hours). Previous advice was that opted-out plant would receive a free allocation equivalent to running at a 45% load factor – this is a significant reduction to the economics of opting-out.
c) The UK has now adopted an approach (National Emissions Reduction Plan or NERP) that will allow our coal plant to run unabated within a sulphur "bubble" during the construction phase – this is a significant improvement in the economics of opting-in.
d) We are now forecasting higher oil and gas prices and that has improved the economics of coal generation.
e) There has always been a strategic case for opting in and that case is strengthening as we see Government increasingly keen to reduce over-dependence on gas and other companies change their position and elect to opt-in. The Government has tilted the playing field firmly in favour of FGD plant and as a direct result, the economics have improved significantly.

Exhibit 2. Methodology changes within the modelling (Source: Business Plan from one of the big six).

[11] The name of the station has been changed to maintain anonymity.

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The economic analysis is based on the value of extra running that FGD will allow together with the additional value of free carbon allowance compared with the opt-out case. This extra revenue is set against not only the capital expenditure on FGD itself but also additional capital and revenue expenditure that take full account of the significantly increased running.

The capital expenditure on the FGD installation is expected to be £211m and by 2015 the central business case has an NPV of £58m with an IRR of 15.6% and an NPV/PV of Capex of 19%.

We then have a further investment decision to make sometime in the run up to 2015 of £100m in NOx abatement equipment. That would allow the station to operate to 2025 and, on the basis of current estimated economics, would increase the central case NPV to £93m.

On the above basis the FGD decision can be regarded as having solid economics out to 2015 on a four unit basis with the potential to improve further under a three unit installation. In addition opting in would give *Station A* the option, but not the requirement, to invest further and secure coal plant out to 2025.

Exhibit 1 below shows how the four unit NPV has changed since the last valuation.

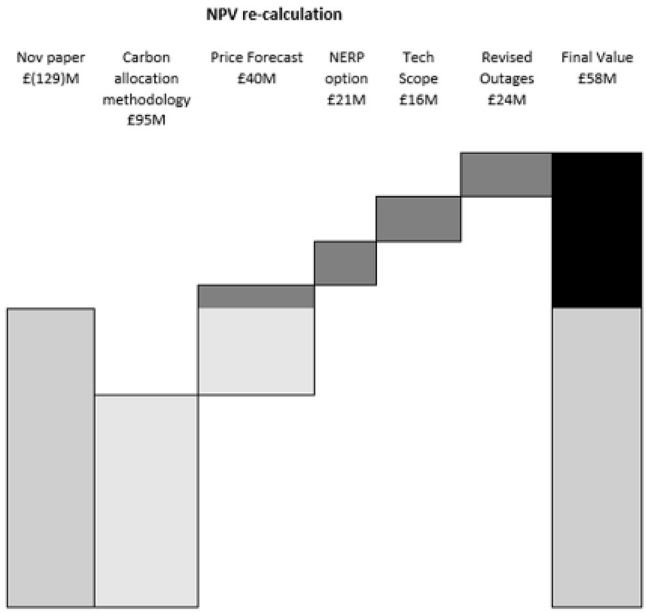

Exhibit 1 - Final FDG value movements - extract from the business plan (Source: Business plan A)

Exhibit 3. Modelling outcomes – *note the reference to exhibit 1 in Exhibit 3 is due to the referencing in the original Business Plan.* (Source: Business Plan from one of the big six).

NPV calculation significantly; i.e. by £93 million for one project. Meanwhile, the emissions allocations methodology also transformed the negotiations between the regulators and industry experts, improving the modelling by £21 million (see Exhibit 3).

The information shown in Exhibit 3 provided the board with sound financial returns. The capital expenditure for the FGD installation was expected to be £211 m and by 2015 the central business case established an NPV of £58 m with an IRR of 15.6%, and an NPV of Capex of 19%. The NPV modelling predictions were used internally to make the investment decision. This was one of the rare examples of a coal plant opting into the directive. The company commented in its business plan that this choice would differentiate it from the majority of its competitors. Their modelling was predicated upon the assumption that future lobbying would succeed, as apparent in the following exhibit from the Business Plan for Station A.

By 2008, all the LCPD investment related decisions had been concluded (see Table 1 for plants opting out of the directive), and many plants were marked for closure, or for investment in FGD to meet environmental targets. Table 1 shows many of the opted out plants were scheduled to close before the anticipated date of 2015. This earlier closure of many plants prompted renewed interest in the security of supply issue, leading to a consultation process for the Electricity Market Review (EMR). Since the introduction of the EMR, the closure of coal plants continued at some plants, such as at the Longannet Power Station, which closed earlier than expected

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Table 1
Opted out plants as of September 2013 (Source: Ofgem, 2012; with updates* from www.RWE.com and www.eon.com).

	Company	TEC MW	Comment
COAL:			
Ironbridge	EON	964	Converting 485 MW to biomass
Kingsnorth	EON	1966	TEC withdrawn 3/2012
Didcot A	RWE	1558	Closed March 2013*
Tilbury	RWE	810	Ceases Q2 2013 Bio-refit?
Ferrybridge 1&2	SSE	994	
Cockenzie	Iberdrola	551	TEC withdrawn 3/2013
Oil:			
Grain	EON	1355	Closed 31/12/2012*
Fawley	RWE	940	Closed 31/3/2013*
Littlebrook	RWE	1245	Reduction to 800 MW at 3/2013

despite opting into the LCPD (Scottish Power, 2016). We will now consider the evolution of the EMR in more detail.

Reflecting on our earlier theoretical discussion of framing, it appeared that there was widespread acceptance that the basic structures of the DCF model were robust (Doganova, 2011), and that the normative language of IA literature was also the natural language of industry players. When first questioned about how decisions to opt in or out of the LCPD were made, all the interviewees cited the same objectives and logic. The use of terms such as 'rates of return', 'hurdle rate', 'NPV', 'IA' and 'scenario analysis' were all embedded within accepted 'values' of the business; all of which can be seen as the material reality forming part of the calculations. When discussing objectives, financial terms were the accepted language among all the stakeholders. Indeed, the basic financial terminology for IA was firmly established, in combination with knowledge about investment funding and the effect of risk on required return.

The practical materiality (Dugdale, 1999) of the IA model was also observed as it facilitated encounters and mediated between multiple frames of reference across finance, regulation and energy policies (Doganova, 2011; Miller & O'Leary, 2007). From the interview evidence, it emerges that the IA model was the central focus of discussions between specialists from different interest groups. In a similar manner to that described in the slide in Fig. 2, and as noted by the interviewees, the IA model enabled knowledge from individuals with diverse backgrounds (such as engineers, environmental specialists, traders, risk specialists and legal specialists) to be translated into readily comprehensible numbers.

4.5. 2008–2017: regulatory dilemmas and spillovers: the emergence of the EMR

As noted earlier, the generators argued that the absence of an established investment policy had hindered their ability to make long term investment decisions. While the regulator understood this, it was inhibited by the key policy objective of delivering low prices to consumers. Ofgem's remit was as follows:

> Protecting consumers is our first priority. We do this by promoting competition, wherever appropriate, and regulating the monopoly companies which run the gas and electricity networks. The interests of gas and electricity consumers are their interests taken as a whole, including their interests in the reduction of greenhouse gases and in the security of the supply of gas and electricity to them. (www.ofgem.gov.uk)

Thus, the regulator had no authority over the generators to force them to ensure a regular supply of electricity. As Ofgem's website stated, they could take action only when a company breached their licence terms, acted anti-competitively, or breached consumer protection law; however, 'failure to make investments' was not governed by any sanction. A Station Manager noted the impotence of the regulators in terms of guaranteeing future investment:

> The regulators, Ofgem, have no legal back up to make us invest. The legal requirement for generators to ensure security of supply was removed through privatization. Of course, Ofgem can play around with the market structure[12] to encourage investment but, so far, they have avoided this because both they and the government believed investment would be market led. This has not worked, market led investment will only work with a strong policy in place.

As the fieldwork for this research commenced, Ofgem was denying that future security of supply was an issue, affirming their primary concern to be guaranteeing low prices. However, given the marketizing framing under which they operated, the objective of low prices was in direct conflict with investors' demands for required rates of return. Following the significant loss of plants through the LCPD, and the investment hiatus that followed, the generators continued to lobby for radical changes to market structure, requesting 'capacity payments[13]' or price guarantees. Eventually, the government accepted the generators' claim that the environmental directives and policies were challenging the pro-competition regulatory model (Stern, 2014), such that pure market-led investment was no longer viable.

The policy outcome in this case was the EMR. As (Ofgem (2015a):1) explained, the EMR 'is a government policy to incentivize investment in secure, low-carbon electricity, improve the security of Great Britain's electricity supply, and improve affordability for consumers.' The government announced two financial incentives to ease the uncertainties raised:

- Feed-in Tariffs with Contracts for Difference (CfDs) – long-term contracts to provide guaranteed revenue to investors in low-carbon generation, i.e. renewables, nuclear, and CCS-equipped plants; and
- Capacity agreements (within a Capacity Market) – payments for reliable capacity to be available when needed, intended to ensure security of supply (DECC, 2011, p. 1).

It was apparent from the White Paper that presented these two new market mechanisms that lobbying based on the NPV accounting information had influenced the changes. For example, the White Paper discussed the need to reduce the cost of capital:

> These long term contracts, Feed-in Tariffs with contracts for Difference (FiT DfDs, which stabilize revenues, would increase the rate of investment and lower the cost of capital, thereby reducing costs to consumers. (DECC, 2011:37)

Both the Feed In tariff and Capacity agreement would be expected to feed into future IA modelling, by influencing both the price and quantity of electricity available within the system. The evolution of energy policy was summarized when, at the end of the decade, the government announced it had come to accept that the industry as a whole required major overhaul, because the earlier arm's length approach had failed to deliver expected levels of

[12] This comment was made prior to the government accepting the market had failed and before the EMR consultations began.

[13] A capacity payment is a payment made to a generator to ensure that the potential for generation is being met.

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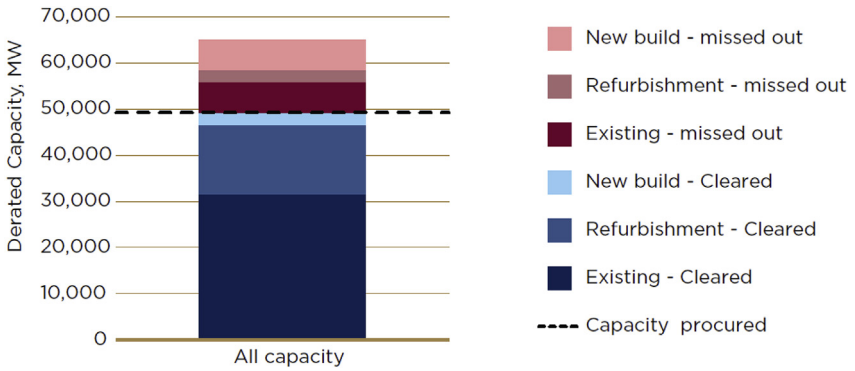

Fig. 4. Allocated capacity contracts (Source: LCP, 2015).

investment. In essence, the agreed solution proposed by the generators was both pro-market *and* pro-interventionist, with a more assured investment climate based on guaranteed prices. As Helm put it:

> It's an extraordinary volte-face to admit that a liberalized market won't achieve its objectives. They have argued against intervention and said markets would engage with the issue of security of supply. The irony is incredible. (Helm as cited in Webb, 2010:1)

The first capacity market emerged at the end of 2014, once the generators has secured the right to guaranteed pricing. However, the clearing price was £19.40 per Kilo Watt, which was far lower than the level required to secure new investment. Fig. 4 shows the consequence was minimal new investment under the first capacity market, with only one large project given the go ahead: the Trafford gas power station, estimated to cost £800 million, to provide a capacity of 2060 Mega Watts. Although the power station was due to begin generating by October 2018, in 2017 no financial backers

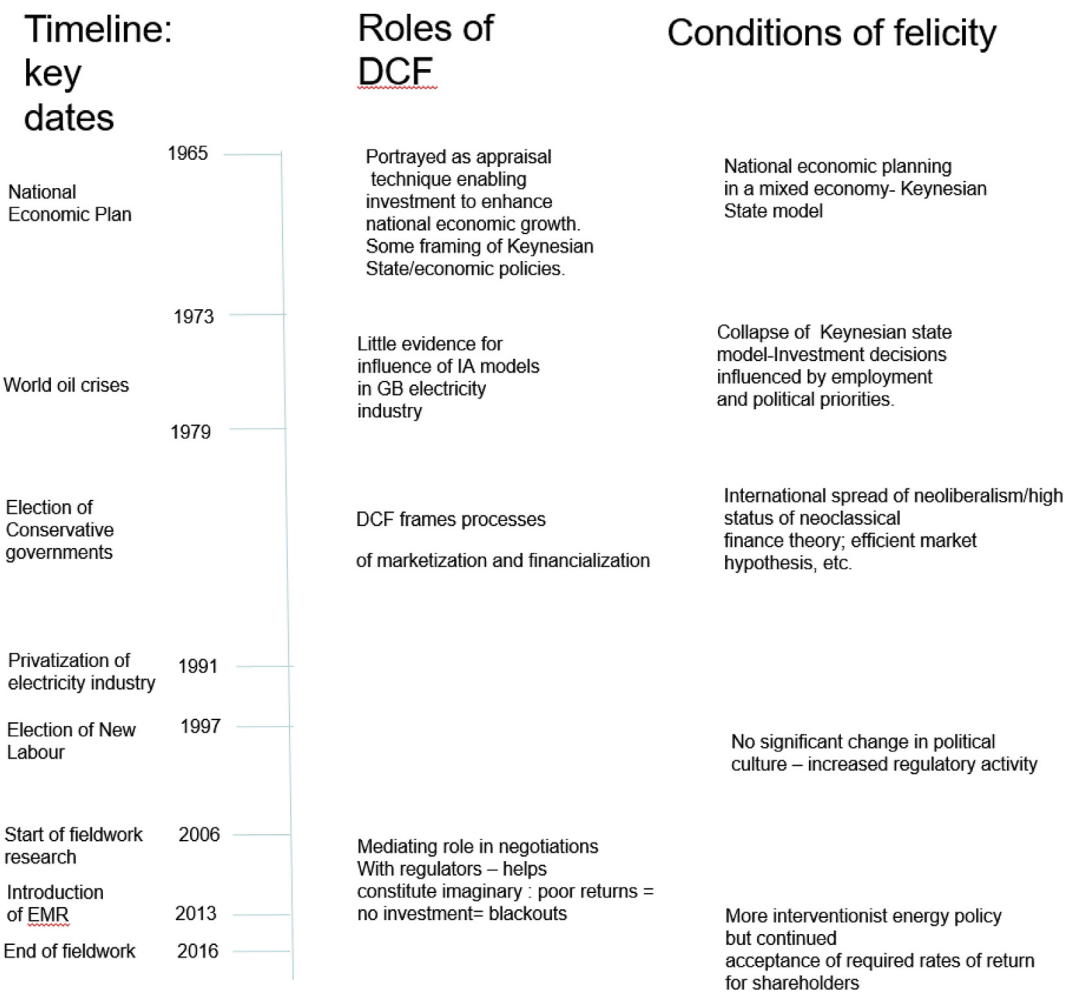

Fig. 5. Electricity industry timeline.

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Phase II carbon allocations: We have been fully involved in the pre-consultation on Phase II carbon allocations for the power industry and observed the stark change in direction by DTI and Department of Environment, Food and Rural Affairs (DEFRA) to overcome their initial rejection of the proposal to use projected load factors rather than historic in deciding allocation methodology for EU ETS power station benchmarks.

The current proposal for projected load factor allocation that is to be proposed by DTI and DEFRA is now based on the hard limit on running imposed by LCPD and also appears to meet policy objectives for GB security of supply. It is deemed to be a robust proposal. There remains a risk that the Government could change their mind back again but we made it clear in a letter from the CEO to Malcolm Wicks, the Energy Minister, that we required a high degree of certainty in order to reach a decision. The new advice from DTI coincided with the extension of the deadline to 3rd February and does appear to be final but allocations will not be confirmed until June 2006 when the National Allocation Plan is published.

Exhibit 4. The lobbying process (Source: Business Plan from one of the big six).

had emerged, because, as explained by a Head of Generation UK:

> There were simply too many price takers; generators with old plants were willing to take low prices as long as it was adding a contribution. So the price makers, the new builds could not compete, and those who tried were not able to secure the investment needed.

Although the first capacity markets promised guaranteed prices, they were set too low and so failed to stimulate the necessary levels of new investment. New investment now depended on fixing higher prices than those set for the first capacity auction. The introduction of the EMR altered the electricity industry landscape in GB, shifting it from a "Liberalized quasi-competitive market into one that is driven by the state" (Helm, 2014, p. 1). The climate policies and regulations created a market reliant on regulated high prices, with the generating companies successfully lobbying the government for economic rents (Helm, 2014).

During March 2016, a consultation process occurred addressing the problem of the capacity market's failure to attract new investment. The consultation document clearly stated, "(T)he overarching message has been that the volume of capacity procured needs to rise and the clearing price needs to increase as a result in order to provide the appropriate incentives for the market to bring forward new gas capacity" (DECC, 2016, p. 1). In order to avoid the problem of auctions that resulted in insufficient finance for new builds, a new proposal introduced a 'Minimum Acceptable Auction Bid' (MAAB), with bidders expected to produce robust financial support plans. This latter requirement was an open invitation to use DCF models as a feature of the "robust" financial support plans, and thus further legitimize the generators' own preferred imaginary, as shown earlier in Fig. 2.

However, despite these fresh incentives, the new system was still not working. Following the consultation process, the Department of Business, Energy and Industrial Strategy (DBEIS) responded, and publically accepted the failings of the new system:

> The government notes the committee's assessment that there are two key failures in the current electricity market: the first relating to security of supply and the second relating to costs on consumers and business … the government has …. struggled to procure sufficient numbers of power stations through the mechanism to ensure long-term security of supply. (DBEIS, 2017:1)

In a complete turnaround from its stance at the outset of this study, the government accepted that the industry was now at a critical point, adding:

> Security of supply should be the first and most important consideration in energy policy. Decarbonisation and affordability must be taken into account, but it should not be prioritized ahead of security where there is any conflict. (DBEIS, 2017:3)

The historical relationships between key political events, the roles of DCF and the conditions of felicity (MacKenzie, 2007) are summarized in Fig. 5. By the end of the fieldwork research period, the essential character of the generators' imaginary had not changed, whilst, in contrast, the socio-economic *agencements* of the industry had changed a number of times. Although the dominant ideology was still neo-liberal in the sense that investments in capitalist markets require the incentive of shareholder related rates of return; crucial inputs into the DCF model and hence the investment decision making process were now potentially underpinned by government guarantees. Although some overflows led to a new, more state interventionist market model, the basic economization, marketization and financialization frames were still driving decisions on investments and IA models, such as the DCF were as robust as ever (Doganova, 2011). The negotiating tactic of withholding new investment has been applied in other regulated industries in the UK. For example, Bowman et al. (2014) found that in the regulated UK telecoms market, industry players, such as BT, used the threat of an investment strike in the development of high-speed rural broadband to obtain public money to subsidize new investment. In the case of the generators, modelling future investments and then presenting clearly negative outcomes regarding supply in a discussion format, assisted their negotiating stance. We will now discuss these outcomes in the light of our CPE framework.

5. Discussion: constructing and de-constructing the investment "crisis"- current profits, rates of return and alternative models of the foundational economy

By drawing the future of the industry into the present (Miller, 2001), the DCF model has helped to constitute an imaginary of

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the current crisis, whereby a lack of new investment in generating capacity could be translated back into outcomes expressed in non-financial terms; i.e. power shortages and blackouts. If the generators' imaginary, as shown in Fig. 2, leads to an accommodating response from regulators (Bowman et al., 2014), then that imaginary can be termed performative; in the sense that it altered *present* reality through the creation of a *future* reality, framed by the logics of DCF and neoclassical economics.

Although the DCF model does not work well under conditions of uncertainty (Doganova & Eyquem-Renault, 2009), it can serve to highlight uncertainties, such as unknown future price curves and unknown future revisions to regulations on energy policy. However, these uncertainties are not based on "states of nature", but rather on the IA discourse of marketization and financialization (Cushen, 2013; Çalışkan & Callon, 2009, 2010), which ruled some solutions *in* (such as guaranteed prices) and others (such as direct public investment) *out*. In terms of Callon's (2007) terminology, the DCF formula has been actualized. As Callon puts it:

> … at a certain point in time, in certain places, the world of the formula is actualized, in such a way that it can be said that the formula describes and represents its world correctly. We are no longer in the register of truth as a reference but – to stick to the same word – in that of truth as success or failure, in truth as fulfilled conditions of felicity. The formula that is born performative, and remains so, seems to be constative when the world (finally) acts according to it. (2007: 321)

As we argued earlier, the influential 'Techno-market' imaginary does not appear to conflict with the emerging EMR policy, even if it seems closer to Green Keynesianism (Levy & Spicer, 2013) than the earlier, less interventionist, regulatory approach. A more fundamental threat to the techno-market imaginary would entail a far more radical change in energy policy, involving direct public investment and ownership which, at the time of writing, has been ruled out. Relating the empirical findings to a review of the performativity thesis, as reported earlier in the paper, prompts the question: how far can the decision to rule out direct public investment be attributed to the framing of the IA imaginary, or is it rather that the contradictions between the techno-market imaginary and the 'material dimensions of economic life' (Levy & Spicer, 2013, p. 662) have thus far failed to generate a crisis? More generally, what are the limits to the performativity thesis? As was shown in the preceding literature review, performativity cannot be separated from materialities and networks. Indeed, Vosselman concludes his review of Callonistics as follows:

> The reviewed studies are supportive of Callon's claim that the performativity of economics is not the simple result of discourses that reflect certain ideologies, values and beliefs, but of power struggles in concrete-contingent networks in which economics and accounting are engaged. (2014:19)

We submit that the CPE framework, and the concept of the imaginary can explain contrasts in energy investment from both a historical and an inter-country perspective. From an inter-country perspective, we note that a framework of *public* investment and control has not only been the preferred model in diverse countries, such as China and France, where attitudes towards state involvement differ from that in GB. From an historical perspective, key investment decisions in the pre-privatization GB industry were primarily correlated with political and engineering logics, not financial ones. The ineffective adoption of a market driven technique such as DCF in a publicly owned industry was unsurprising, since, in the absence of private property rights and a functioning bankruptcy court, market signals were not "real" (Wiseman, 1973). In sum, under a CPE framework, discoursal and the material dimensions are mutually supportive. The expansion of the private market sector encourages the spread of financialized thinking, as encapsulated in the DCF/point value complex (Bowman et al., 2012), which provides a market device that mediates the negotiations between public, quasi-public and private entities.

A CPE perspective that draws on the performative concepts of spillovers offers a response to the question of why in GB (to date) direct public investment in electricity generation has been ruled out. Herein, we have focused on an economic imaginary framed in terms of financially-oriented IA models that bias discussions towards market-led solutions. Yet noting the inevitable presence of spillovers (Callon, 1998a, 1998b), our fieldwork reveals inherent limits to the "free" market, resulting in policies that involve a very flexible invocation of the DCF model in the service of proposals for a variety of market interventions and subsidies. These findings support the more general observation that the imaginary of the modern capitalist state offers a curious, contradictory mix of state and private action (Jessop, 1982). For example, the GB state currently spends billions on welfare but cannot (or will not?) build power stations. From a neoliberal perspective, the state cannot become "productive", because that would then subvert the central role of private capital. Jessop (2013) argues that this laissez-faire perspective might change, as crises generate new solutions and new imaginaries. However, as previously argued, what constitutes a crisis may itself be difficult to define (Roubini & Mihm, 2011). In the case of electricity generation, the predicted crisis is denoted by blackouts and power cuts. However, as noted earlier in the paper, electrical power cuts have failed to trigger fundamental changes to the ideological presumptions behind private supply (Weare, 2003) in countries such as the USA. Indeed, from a CPE perspective (Cooper & Sherer, 1984; Tinker, 1980), and in contrast with their negotiations with the regulators, a crisis *for the generators* has typically had very distinct *economic* characteristics. In short, crisis is *not* defined by electricity blackouts, but rather by a fall in the rate of profit and/or threats to private ownership of the means of production (Miliband, 1969).

6. Conclusions

Building on the literature on performativity and CPE theory, this paper has shown the prescriptive calculative techniques of IA, particularly DCF, can serve as economic prosthetics, enabling the economization, marketization and financialization of private and public policies on investment in new generation capacity. We have also shown, using original fieldwork, how the DCF model was deployed as a mediating device in negotiations on prices, technologies and costs, even where the main thrust of the regulatory effort was directed towards non-economic environmental goals. The empirics revealed that a key imaginary was based on the point value logic of the DCF model deployed by the generators who, whilst under pressure to meet environmental demands, raised the possibility of an investment hiatus resulting in power cuts and blackouts. The fieldwork demonstrated how the normative model of IA played a key role in framing the negotiations between the generators and regulators, bringing the future into the present (Miller, 2001), and translating a diversity of scientific, technological and economic data into a single metric. Although there were multiple loci of calculation, a shared market and point value imaginary was both enabled by, and enabling of, DCF/NPV logics.

Furthermore, the DCF model played an objectifying role, by masking the genuine concerns of the generators, whilst limiting the choices apparently available to policymakers. In summary, the

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discourse of crisis, as associated with blackouts, masked the probability that the generators would themselves define crisis as falling rates of profit, or threats to private property rights. Despite its technical limitations as an investment evaluation technique, the DCF/NPV model emerged as a subtle, yet powerful, actor, responsible for mobilizing a variety of key players in negotiations on electricity prices and technologies. The power of the model was implicit, as it framed the terms of reference of the negotiation within a wider imaginary of markets and competition. One of the supreme ironies to emerge, is that, whilst it is not clear to what extent the actors who actually make investment decisions based their judgments on theoretically approved IA techniques, the political, economic and regulatory debates were framed by the language of rates of return and discount rates.

To date, in the case of the GB electricity industry, the fundamental imaginary of market-led solutions has not been challenged. Different market experiments have been undertaken, involving a contradictory ideological mixture of limited state intervention and public subsidies and guarantees. From a public policy perspective, the political frame seems to be more myopic than the investment frame, reliant on short-term proposals that bribe industrial consumers to limit their electricity consumption as power shortages threaten. Furthermore, although clearly in the interests of the regulators to link issues of pricing and investment, as IA models do, it is less clear why other players have failed to question the underlying logic.

One of the strengths of the theoretical and methodological frameworks of CPE is that semiotics and materiality *both* matter. It is perhaps unsurprising then, that it was in the economic interests of the generators to construct imaginaries based around DCF models. Certainly, it is rather more surprising that, while environmental targets initially played a significant role in the discourse surrounding the future of the generation sector in the UK, as time went on, the performative role of IA highlighted the capacity concerns of the generators and think tanks to push a market design policy increasingly towards security of supply. If this conclusion suggests finality, then we might heed Callon's warning when he states, 'the game is never over, for new framings are always possible, always involving a *bricolage* of both the *agencements* and the statements' (2007: 321, original emphasis).

Appendix 1

Data collection stages and methods

Data collection – stage	Stage one: Initial consultation with industry experts to identify industry *hot* topics.	Stage two: Gaining technical understanding of regulations.	Stage three: Collecting LCPD documentation – regulation applications.
Method	• Initial unstructured interviews • Attending industry conferences • Collection of White Papers and public presentations	• Attending industry conferences • Informal discussions with industry experts • Collecting EU directives	• Unstructured interview with Strategic Environmental Officer of EA • Physical visits to some regional EA offices to collect information • Virtual collection of some documentation from the EA regional offices who operated in this form.
Notes	All methods include collecting data from consultants, analysts, generators and regulators.	Conferences attended included '*Kyoto – at what price*?' London June 2006 and '*Implementing EC emissions directives*', Germany, November 2006. The stakeholders included in informal discussions include regulators, associations, generators, Transmission team, Trade Unions, consultants, analysts, trainers.	The interviews were necessary to establish which stations had opted in and out - at this stage there was no information publicly available. During the collection stage, it became apparent that each regional office had requested different information and some had used documents as their personal libraries, resulting in much of the information being unavailable.
Time period	2006	2006–7	2008–9

Stages 1–3 of data collection.

Data collection – stage	Stage four: Secondary data collection on industry background	Stage five: Primary data collection on industry background and current decision making process	Stage six: Triangulation of information
Method	• Collection of White Papers • Collection of historical studies about the industry	• Semi-structured interviews with actors in the industry with knowledge ranging from 6 to 40 years spent in the industry.	• Attendance at two key industry conferences, *The Energy Forum Annual Conference,* London, Oct 2010 and 2011. • Industry debate, Institute of Directors led by Professor Dieter Helm, London, Oct 2011.
Notes	This collection process included industry and academic sources.	Companies interviewed included Scottish Power, International Power PLC, Drax, RWE Npower, Credit Sites, E.on, UK, and the Environment Agency. Interviewees were recruited through contacts made at previous industry conferences, initial interview stages and cold calling. Letters were sent out via email and followed up via telephone.	Attendance was twofold: first, to gain new knowledge about the latest White Paper, and second to triangulate information gained in stage five, with the knowledge of CEOs from the big top six energy companies and regulators. Key informants included the Minister of State, and actors within Scottish Power, International Power, Accenture, KPMG, Powerfuel, Mainstream Renewable Power, Costain, Citigroup, EDF, and PWC. Government consultations/White Paper regarding EMT accessed.
Time period	2009	2009–10	2010–12

Stages 3–6 of data collection.

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Stage seven: Updates of auctions, EMR and consultation process in 2016 (Time period 2012–2016)

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